Design Engineering

FIVE DOLLARS A YEAR

AUG 6 1959

August 1959

Electron microscopy 23

Meter relays 33

Mechanical vibrations 42

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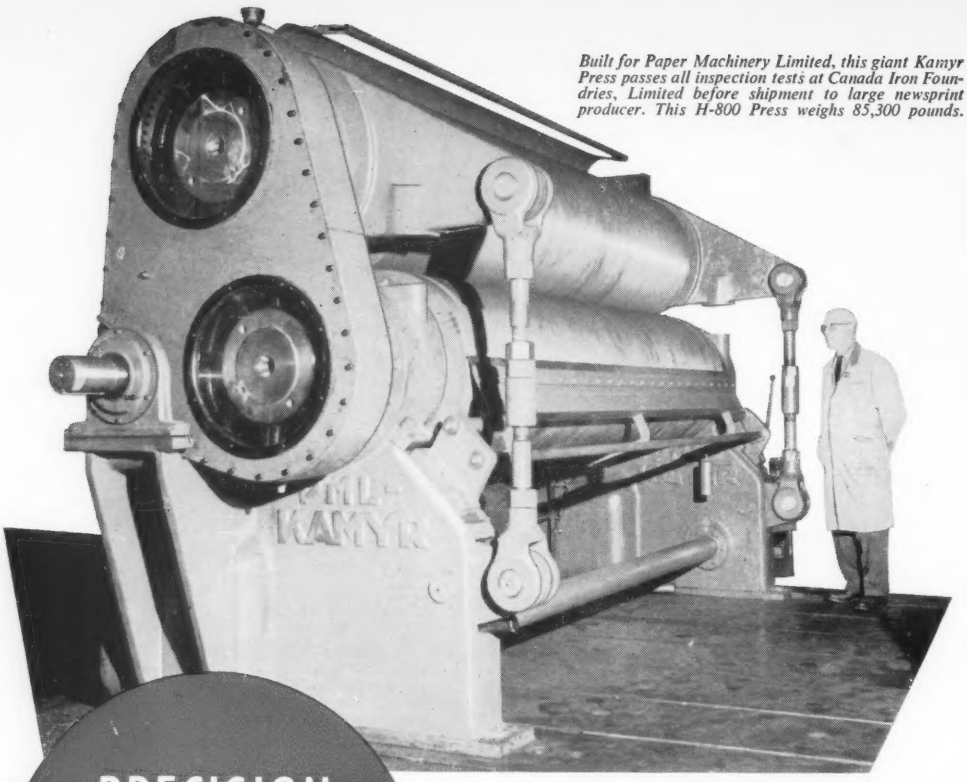

Built for Paper Machinery Limited, this giant Kamyr Press passes all inspection tests at Canada Iron Foundries, Limited before shipment to large newsprint producer. This H-800 Press weighs 85,300 pounds.

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Design Engineering

Vol. 5 AUGUST 1959 No. 8

This month's cover

Silhouetted is an electron microscope. In orbit are microphotographs of clusters of cementite particles and needle and rounded particles from tempered steel, and others. Magnification is up to 85,000 times—though in stubborn cases x350,000 is in order. This raises interesting speculations like: "When does a pin head become the size of the Empire State Building?" And if there's a moral here, it's probably: look after the molecules and the mountains will look after themselves. Jim Rowland did the artwork.

Design Engineering

MEMBER

CCAB

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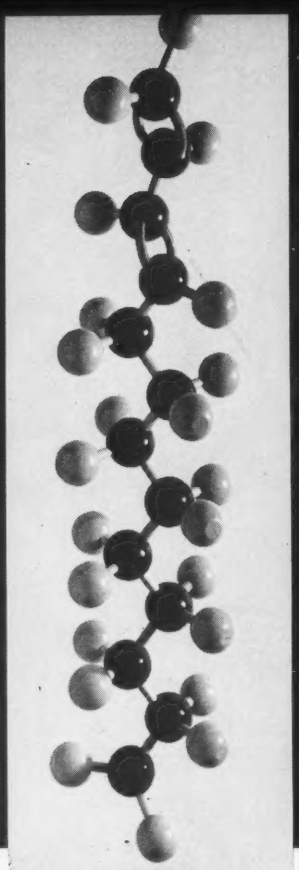
DU PONT OF CANADA LAUNCHES A NEW ERA IN CANADIAN PLASTICS



...with the production of linear polyethylene resins

the most important plastics discovery since nylon, in a plant engineered by Canadians for Canadian requirements

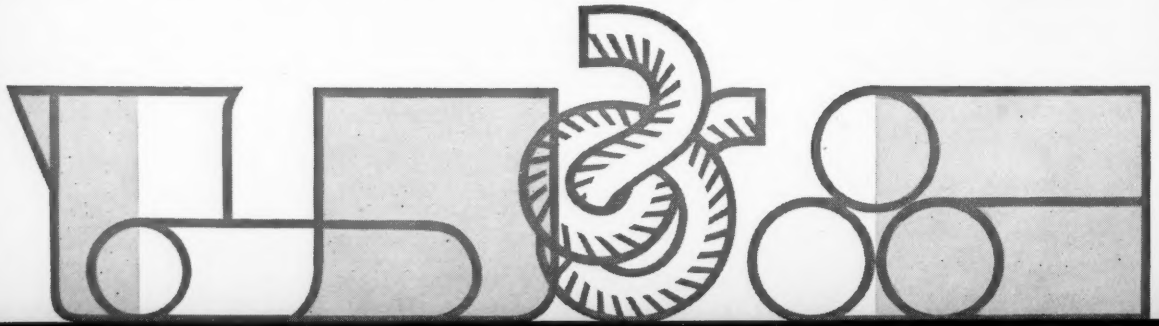
As part of its dynamic 1959 expansion program, Du Pont of Canada is constructing its St. Clair River Works near Sarnia, an ultra-modern plant engineered specifically to Canadian market conditions for the manufacture of revolutionary linear polyethylenes. In addition, Du Pont has built a $300,000 sales service laboratory at Kingston, Ontario, where research into their exciting consumer and industrial applications will take place.

First announced just five years ago, linear polyethylenes are an amazing new family of resins far more rigid and heat resistant than the original squeeze-bottle material. The plastic products that can be derived from them are not only impervious to chemicals, abrasion and vapor, but their hitherto unmatched properties are expected to introduce unique new value into housewares, wire and cable, containers and piping, to mention only a few of the fields so far explored.

Be sure to watch for these remarkable new plastics from Du Pont of Canada, marking the greatest advance in plastics technology in over two decades. Enquiries about this superior Canadian-developed material are now invited.

DU PONT OF CANADA LIMITED

DU PONT CANADA



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Krebs

Another bachelor takes up the pen

Glenn Krebs is an engineer with a flair for living. He drives a Jaguar, likes modern jazz and used to design and build hi-fi sets. Krebs is apparently conservative in winding-up his car — but really guns the gain to decibel ranges on his music-box. This may be one of the reasons he is single. He is in charge of engineering in the "packaged" control department of Assembly Products Inc., was a U. S. Army instructor on fire control, has been electronic designer on analog computers.

Bench and sheepskin

One of our authors served an apprenticeship in England in machine tool making before qualifying as a professional engineer. In fact **Trevor Beard** came to Canada to get his B.A. Sc. (Mechanical) from the University of Toronto. Since then, he's headed up a firm of welding specialists, lectured evening classes and confesses to particular interest in hydraulics and electrics. Beard seems to be a family man—because when we asked him his hobbies he looked incredulous. Cut bears this out. Not only are his hands full—look at the way he's fenced in, an ominous sign.

Cooperation gets results

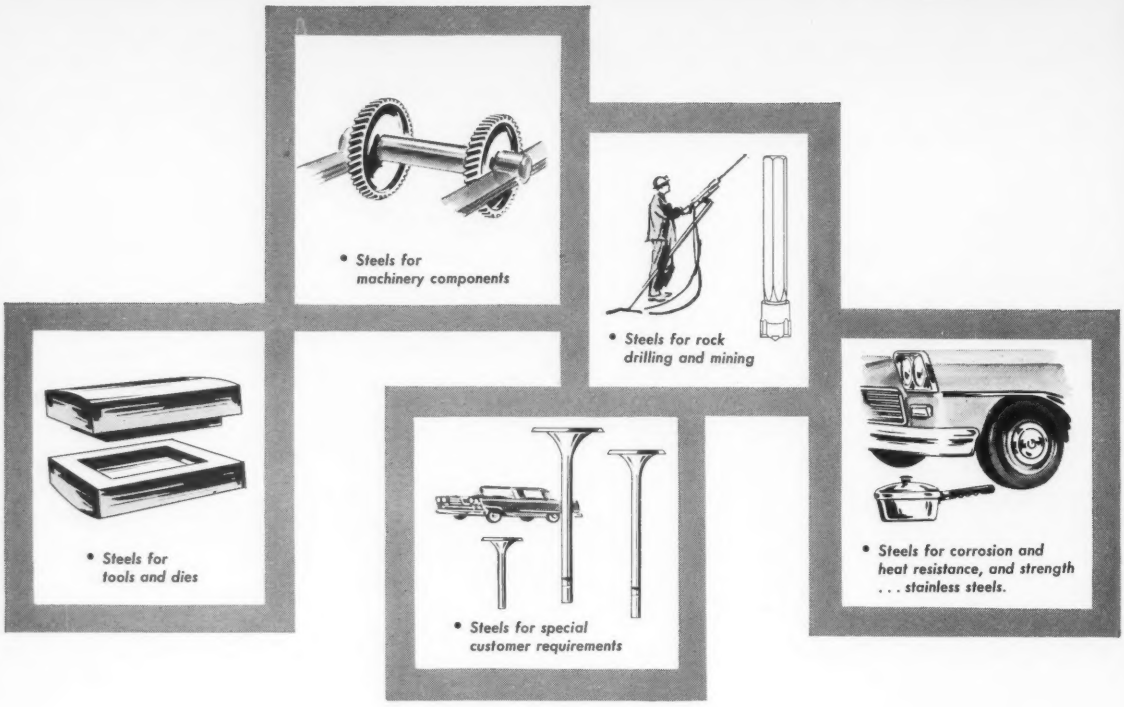
Graduating from University of Toronto with a B.A. in Chemistry and a Ph.D. in Physics, Hamilton-born **F. W. C. Boswell** joined the Department of Mines and Technical Surveys in Ottawa. This was the Physical Metallurgy Division, where he set up a lab for electron microscopy and electron diffraction, and applied these techniques to the study of structures of metals. The fascinating results of some of his work are seen in this issue. Since 1957, head of the Metal Physics section, Boswell's favorite hobby is color photography.

Collaborating on the electron microscopy article is **E. Smith,** a cricketer from Preston, deep in the heart of the silly mid-on belt of Lancashire. After a spell in the army, he went up to Cambridge to take his M.A. and Ph.D. degrees in metallurgy. Coming to Canada in 1957 as a National Research Council Post-doctorate Fellow, he worked at the Mines Branch on an electron microscopic study of iron. In 1958, he joined NRC to continue his work in this field. We believe another of Smith's hobbies is model railroads.

Deep sea fishing relaxes

New Yorker **Robert B. Sterns** tells us he has been designing and building advanced electronic control systems since 1947. The projects he undertook for engineering construction firms convinced him of the great potential of the automatic control field. Since then, he has devoted all his professional time to the subject. Sterns has an engineering degree from Columbia University; has taught engineering at the U. S. Merchant Marine Academy; served as an officer in that service. Deep sea fishing is the way he likes to relax.

Beard and bairns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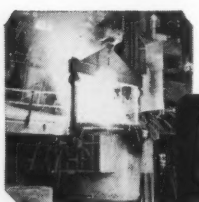

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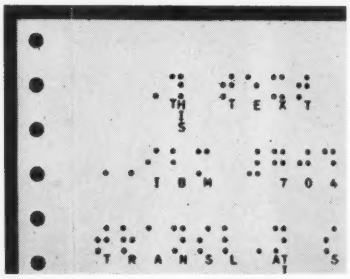
Reports

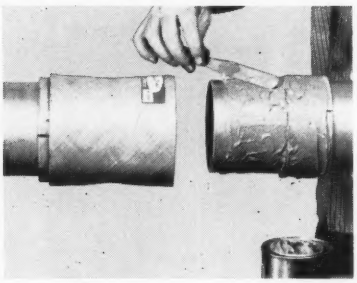
A news roundup of items of engineering and design interest from the world over

How to translate a book into Braille in one hour



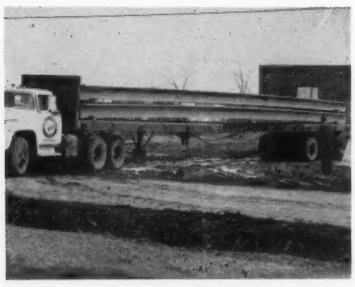
A recently developed electronic computer can convert a 300-page book into Braille in one hour—a job which would take skilled operators more than six days to do. The procedure creates in minutes a raised printing plate suitable for the production of books. The computer operator doesn't have to be trained in the Braille system, either. Texts to be translated are first transferred to punched cards, and these fed to a computer which executes 600 instructions per word in less than 1/40th sec. If the word "changeable" is to be translated for instance, a human transcriber would convert it into seven Braille characters. The IBM 704 goes through hundreds of separate steps to get the same result —but in a sliver of the time. Cut shows a sample of the preliminary print-out for editing.

Flexible pipe resists corrosive elements



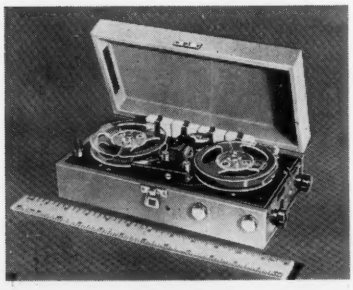
This reinforced plastic pipe was successfully tested in fresh, salt, and waste water, sewage, oils, solvents, foods, beverages, gasses and other corrosive materials. The specific gravity of the fiberglass and epoxy material is one fourth that of steel according to Amercoat Corp. The wall thickness, however, is about half that of equivalent steel pipe. Easily cut and joined in the field, the pipe requires no special tools. As photo shows, joints can be made with a locking wedge and O-ring, and secured by an adhesive which seals the joint permanently against leakage. Although rigid, the non-flammable pipe is sufficiently flexible to follow the contour of a normal ditch and, we are told, will not cold flow or sag when in use.

Nothing like a bit of Brahms in a trailer design



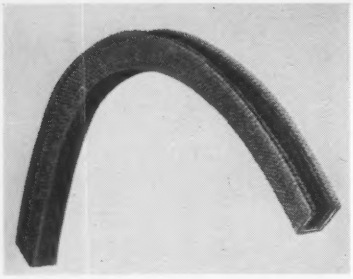
Because of diversified payloads, a Belleville, Ont., firm of contractors needed a trailer to perform the work of two. The outbound haul was bagged cement, whereas the inbound run was five pre-stressed beams 53-ft long. Throwing the problem at the trailer builders, they got something of a musical answer. A three axle trombone-type unit that extends from 36-ft to 54-ft and will carry 25½ tons was advocated. When extended, the centre of the trailer is an open framework of two parallel side members of boxed-beam construction. An X-pattern is formed by two tubular cross trusses extending from corner to corner. Lock-type pins extend through side members. When the trailer is closed, tubular trusses are carried on or under the unit. The Fruehauf Trailer Co. designed and built the rolling sliphorn.

New recorder is small, compact, lightweight



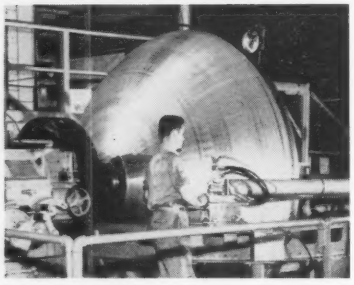
Sling this 4½-lb. tape recorder over your shoulder and you're ready to meet most professional assignments, the makers tell us. Operating from batteries, the unit records at standard speeds of 7½ and 1⅞ ips and has a high-frequency response of 50 to 12,000 cps. Assisting the miniaturization (recorder measures a mere 9½ in. x 5 in.) is the fully transistorized design and an automatic charger for the four two-volt batteries. The recording time varies from 18 min. per spool (9 min. on each track) at 7½ ips., to 72 min. (36 min. on each track) at 1⅞ ips. The microphone is carried in a pocket on the shoulder strap and the set has a hi-fi output socket. To complete the picture, the British-made Fi-cord records in any position—open or shut.

Keep out the weather with U-shaped channel



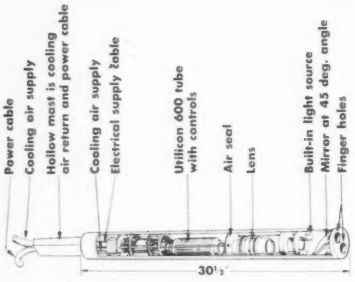
We thought it was a de-capitated caterpillar too. It's really a flexible woven pile channel designed for contoured applications. The U-shaped channel incorporates silicone-treated pile to give positive resistance against moisture and wetting. Interwoven wire adds strength and form. Immediate applications are seen in the automative, marine and aircraft industries where window openings are of irregular shape. The pile is apparently an effective barrier against wind and rain, is impervious to heat or cold and acts as a silent, self-adjusting, stick-proof bearing, refusing to wear out. The Queen of Hearts could have used it for croquet hoops instead of those poor, creaking soldiers, but the Schlegel Mfg. Co. hadn't developed the idea then.

Electronic system aids in metal-spinning



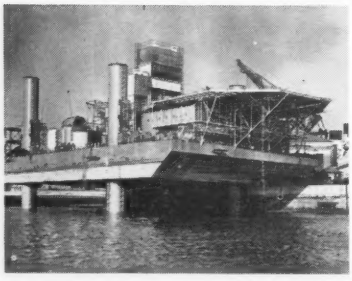
The fuel tank head shown in photo has a diameter of 105-in. and is said to be one of the largest thick-walled vessels ever spun. Made of 5086 aluminum alloy, the part was spun from a 139-in. circular blank 7/16th of an inch thick, and over-all machined to produce the required thickness tolerance. Optimum strength at minimum weight was achieved by leaving heavy areas as required for subsequent attachments by welding, say U. S. Chemical Milling Corp. The lathe was specially built for the job, and makes it possible to machine one side relative to the other wall for thickness control. Hydraulic tracer controls regulate the cuts, but a constant reading electronic system shows at all times the actual thickness being machined.

Midget tv camera is Peeping Tom inside reactor



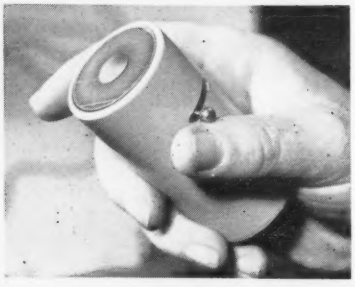
Drawing shows a TV camera called "Pencil". Nicknamed because it is just 2¾-in. wide, the camera allows critical inspection of welds inside 3-in. reactor tubes. Camera is mounted on a handle of rectangular tubing so that it can be inserted in the tubes. Handle also carries the power cable and cool-air feed for camera, together with an exhaust duct. A 17-in. TV monitor and camera control power unit make up the system, developed by the Diamond Power Specialty Corporation. These two units are mounted on a cart for ease of movement to inspection sites. The reactor tubes (stainless steel), blacken under radiation, but defective welds show as clean area. The enlargement of these areas on the TV screen allows accurate analysis of tube weld condition with safety.

Air-conditioned adventure in the Far East



Ahoy there! How about a stint aboard this oil-drilling platform in the South China Sea. It's fitted with a helicopter landing stage, has air-conditioned accommodation for 56 men, and can withstand a wind force of 100 mph. Built at Southampton, England, by Steel Structures Ltd., the platform contains 3,000 tons of steel and is used for exploration drilling off the west coast of British Borneo. The platform is fitted with four retractable legs 235-ft in length and 10-ft in diameter. When the drilling site is reached, the legs are lowered until they reach the bottom of the sea. A powerful hydraulic mechanism is then engaged which enables the rig to climb up on its own legs so that it is clear of any lifting action of the waves.

Artificial larynx relies on batteries for power



The power of communication for persons who have lost their voice through the surgical removal of their vocal cords, is sharply increased with a new artificial larynx. The instrument, according to top Canadian surgeons, is especially effective when used for telephoning. By means of a finger-operated switch and inflection control, the user regulates pitch of his artificial voice, giving to speech a natural sounding quality. Principle is a vibrating driver (transducer) held against the throat. It contains a modified telephone receiver, transistorized pulse generator with pitch control and battery power supply. Printed circuits will be used for miniaturization. A Bell Telephone Laboratories project.

Ni-Resist* ductile irons

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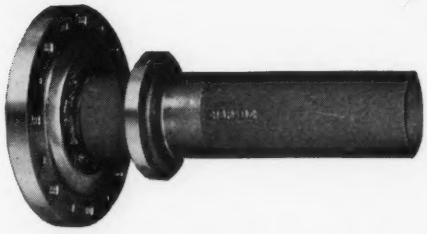
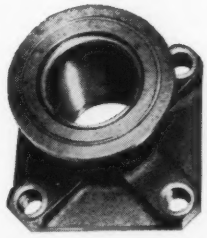
Machinability—Because Ni-Resist ductile irons have graphite in their structure they machine readily.

Fluidity in casting—Intricate designs can be made because Ni-Resist ductile irons have good castability.



Application: Overflow nozzle for Bauer pulp stock cleaner. *Requirements:* Corrosion and wear resistance with high strength. *Material:* Ni-Resist Ductile Iron Type D-2. *Producer:* Canada Iron Foundries Limited.



Application: Bushing at base of insulators on the dome of an electrical circuit breaker. *Requirements:* Non-magnetic, corrosion resistant. *Material:* Ni-Resist Ductile Iron, Type D2C. *Producer:* Canada Iron Foundries Limited.

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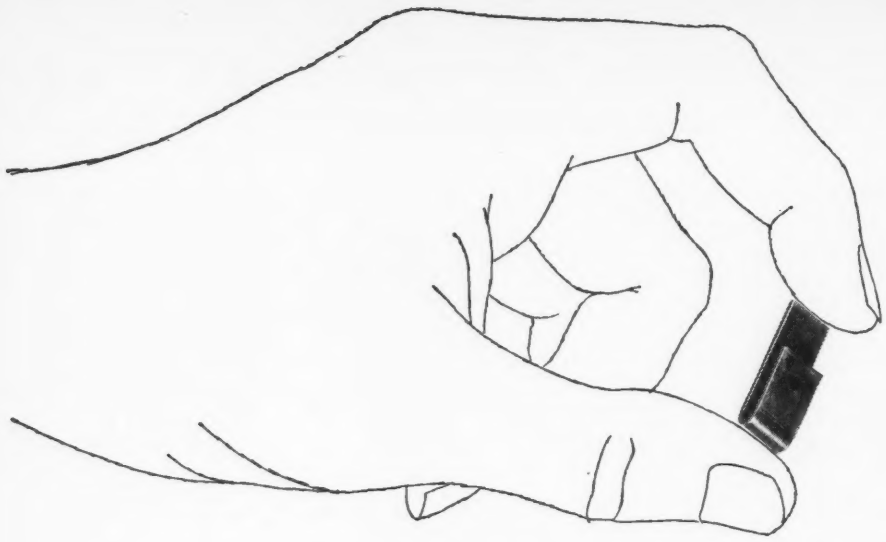

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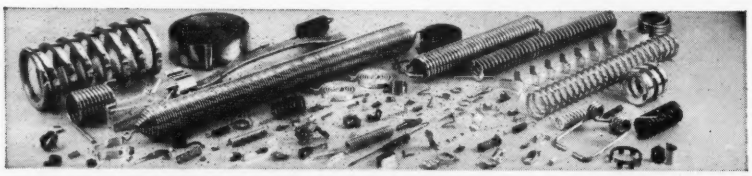

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Garlock Seals "spare" pinsetters from loss of vital oil

Garlock Klozure* Oil Seals help assure dependable operation of Brunswick-Balke-Collender automatic pinsetters by eliminating oil leakage from the gear box. At the same time, they prevent damage to the bearings by sealing out dirt and dust.

Reliability is the prime reason for specifying Klozure Oil Seals, according to Brunswick. The Seals have been in continuous use for 3½ years!

Your product, too, can enjoy long, trouble-free life like this; simply design Klozures into your application. Standard Klozures are resistant to grease and oil . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . applicable from −40° F to +250° F. For extreme service conditions, Klozures are available to withstand any fluid and temperatures as high as +500° F.

Klozure Oil Seals are another part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Klozure Catalog 30.

*Registered Trademark

THE GARLOCK PACKING COMPANY OF CANADA LTD.

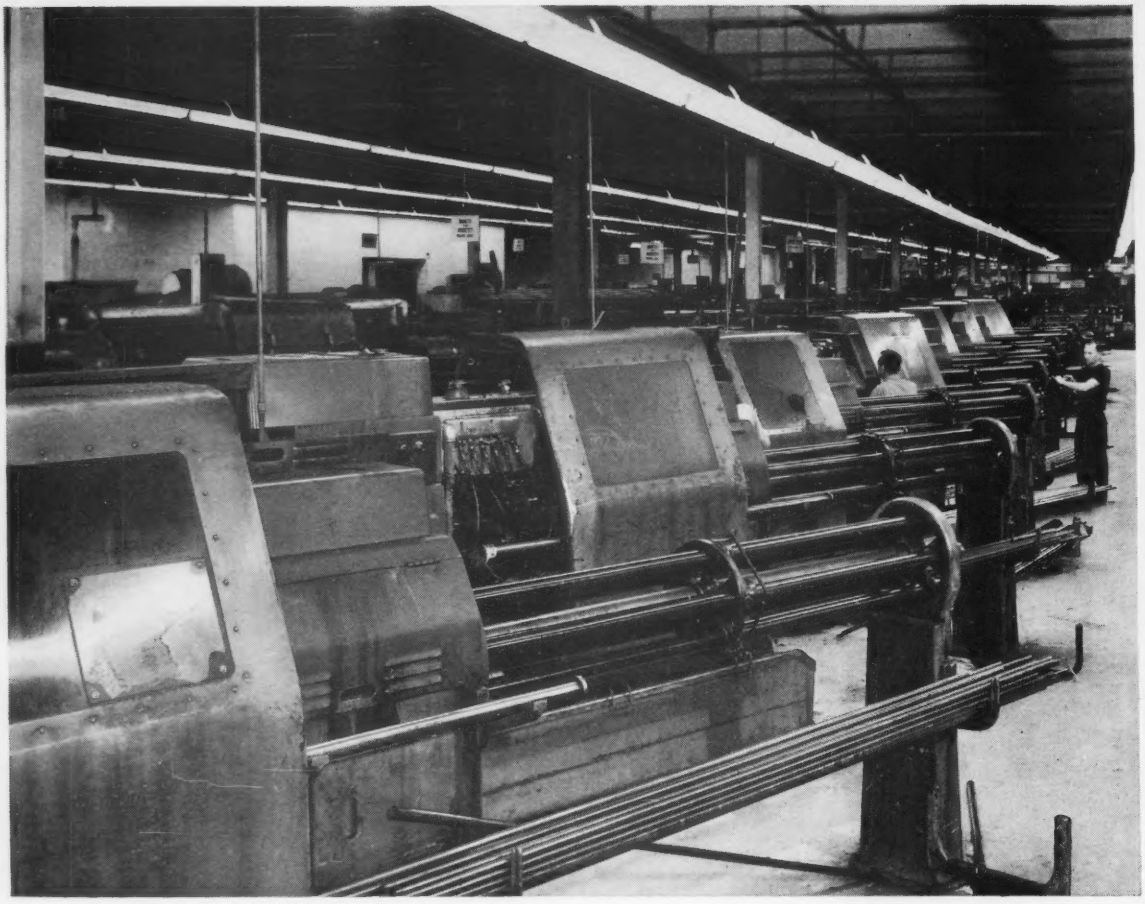
● General Offices: Toronto, Ont.
Branch Offices: Hamilton, Montreal, Winnipeg, Edmonton, Vancouver

GARLOCK

Canadian Division: The Garlock Packing Co. of Canada Ltd.
Plastics Division: United States Gasket Company

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Add this shop to your production team



Cut overhead... increase production!

Let Weatherhead produce all your screw machine requirements. Save on the cost of components and reduce your machine load.

A battery of 66 multiple and single spindle automatic screw machines are capable of machining from 1/32" through to 2 5/8" diameter material. These and other secondary operation machines are ready to go to work for you.

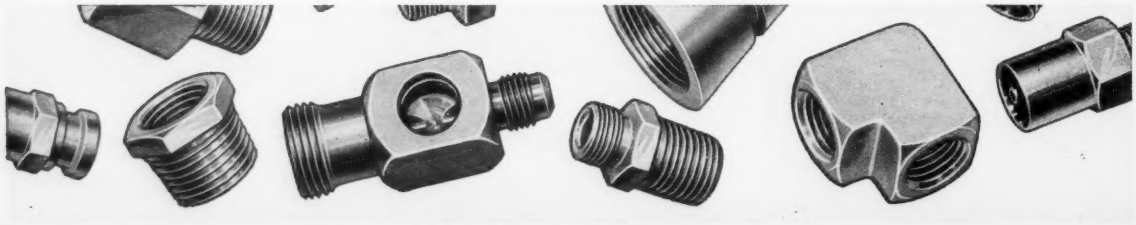
Specify brass, steel, aluminum or any machineable material. For the highest production quality, in any quantity at the lowest cost—call in Weatherhead. Complete engineering facilities are available.

WEATHERHEAD

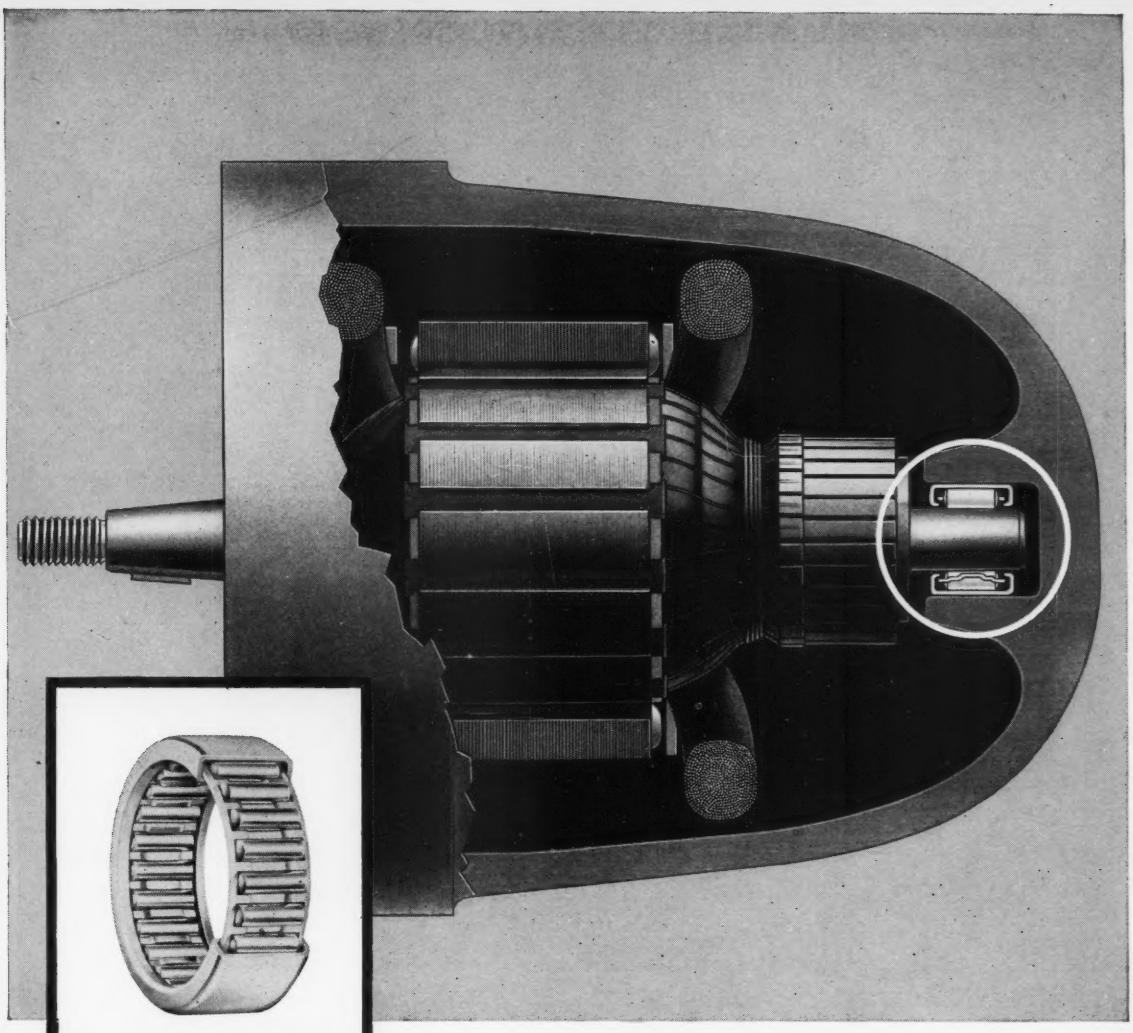
BUY CANADIAN

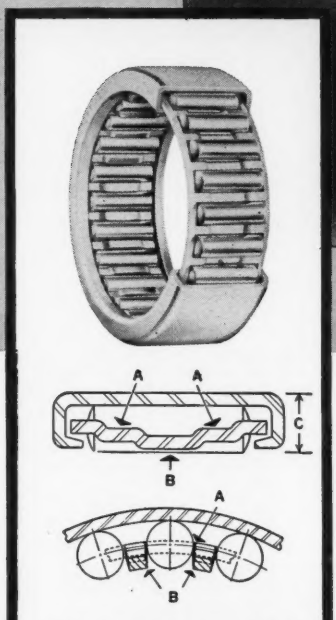
SCREW MACHINE DIVISION
St. Thomas, Ontario

SM-4-9



Circle number 138 on time saver card





- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Save up to 50%
on armature bearing costs!

Low unit cost of the new Torrington Drawn Cup Roller Bearing reduces armature bearing cost as much as 50%. This unique bearing gives excellent service at high speed and permits prelubrication for life.

Test installations and service applications show the bearing performs efficiently at speeds up to 25,000 rpm in intermittent service of 1000 hours and more. In such service, initial lubricant lasts the life of the motor. Most applications require no seals. This, with the simplicity of housing design, contributes further to economy.

Designers are invited to evaluate the Torrington Drawn Cup Roller Bearing for such applications as generators, power tools, electric mixers, vacuum cleaners and other appliance motors where considerations of cost, speed, efficiency and light weight are paramount.

Services of Torrington's engineering staff are offered to assist you in design developments of every type of electric motor. **The Torrington Company, Limited, 925 Millwood Road, Toronto 17, Ont., Canada.**

TORRINGTON BEARINGS

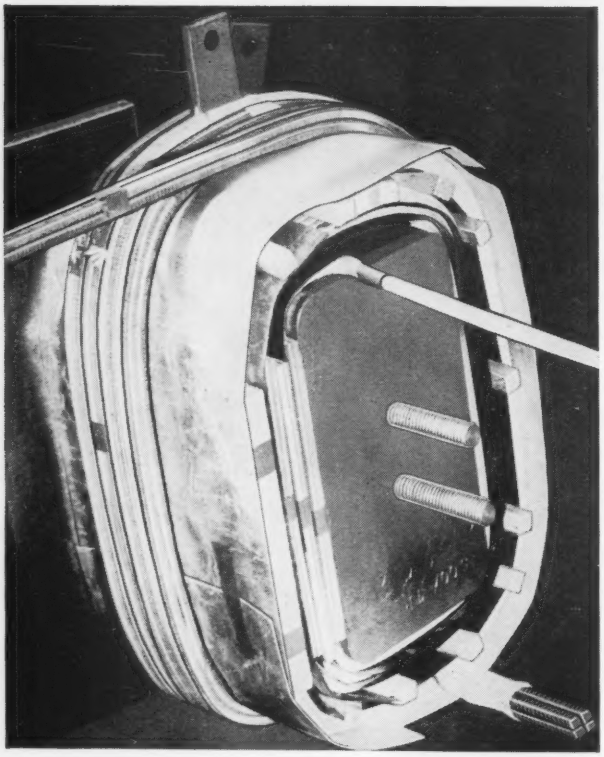
District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Circle number 135 on time saver card

lower production costs

on "Class B" and "Class F" windings with



FEDERAL
DAGLAS* MAGNET WIRE

Unique mechanical properties, such as extreme flexibility, resistance to abrasion and damage from forming, make Daglas magnet wire the ideal material for all "Class B" and "Class F" windings.

Daglas magnet wire consists of bare or enamelled copper wire, wrapped with a combination of Dacron and glass and heated to fuse the glass fibres in place. An overall coating of varnish is applied, providing a smooth finish and improved resistance to abrasion. Daglas can also be supplied without varnish if required.

Daglas is supplied in square and rectangular sizes from #14 to #1 AWG and in round sizes from #23 to #1 AWG, with "Class B" and "Class F" ratings.

Daglas has greater flexibility. In sharp bends where ordinary glass insulation cracks badly, Daglas leaves no wide open cracks—adheres perfectly.

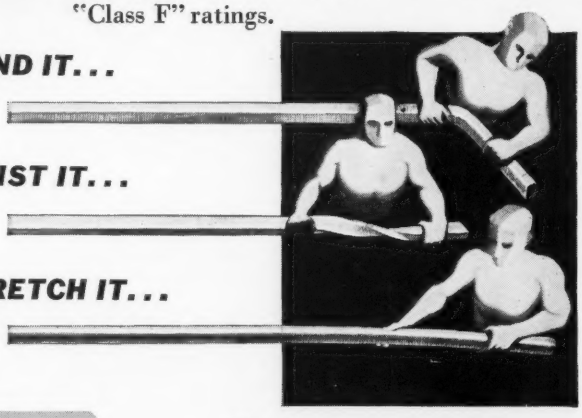
Superior adhesion of Daglas insulation prevents unravelling and separation even when twisted. Greater resistance to damage from abrasion.

When conductors are elongated to breaking point Daglas still adheres tightly—no fraying at the ends and no unravelling as with ordinary glass insulation.

BEND IT...

TWIST IT...

STRETCH IT...



5902

*Phelps-Dodge registered Trade Mark

FEDERAL WIRE PORTER **& CABLE DIVISION**

H.K. PORTER COMPANY (CANADA) LTD.

DIVISIONS: Connors Steel, Delta-Star Electric, Disston, Forge and Fittings, Leschen Wire Rope, Mouldings, National Electric, Refractories, Riverside-Alloy Metal, Thermoid, Vulcan-Kidd Steel, H.K. Porter Company (Canada) Ltd.

Circle number 127 on time saver card

A NEW LOOK in Locomotives with VIBRIN PLASTIC SURGERY

How do you style a locomotive at a mass production price? You take a leaf from the book of a large Canadian manufacturer of Diesel-hydraulic locomotives... You use VIBRIN polyester resin — for example — to mould the large complex parts having compound curves such as the nose sections and the cab roof.

That's the beauty of VIBRIN reinforced with glass fibres. It's so light and so very strong, so obedient to moulding and loyal to shape, it's proving the ideal answer to a multitude of problems.

In addition to these locomotives specially designed for export, scores of different water craft are made of VIBRIN today, as well as hundreds of aircraft parts, swimming pools, car bodies, machine housings and what all. Most manufacturers like VIBRIN because it's stronger than steel of equal weight. Just as many, favour VIBRIN because it's rust and rot-proof, and a natural insulator. And *all* go for VIBRIN because it *never* requires expensive tooling.

VIBRIN will repay your interest a thousandfold. Write for *all* the surprising details and comparisons today.

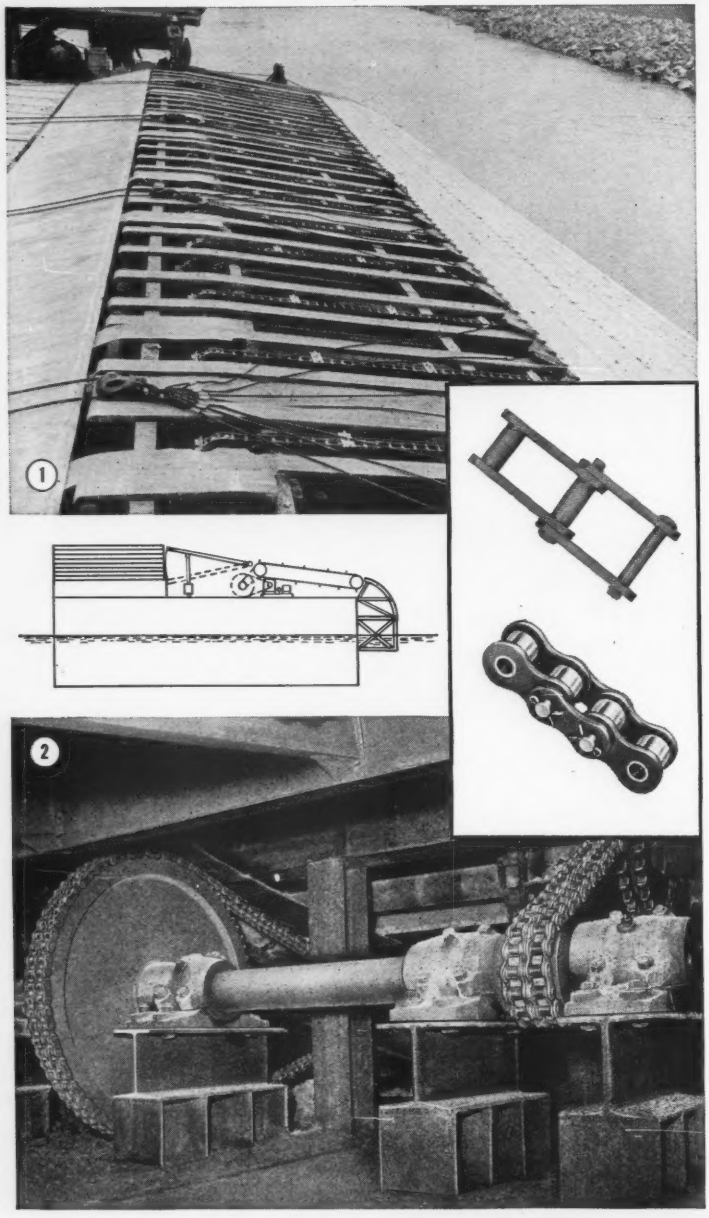
Other NAUGATUCK Plastics

Vibramix — Polyester Premixes
Kralastic — Styrene Copolymers
Marvinol — Vinyl Resins

Naugatuck Chemicals
DIVISION OF DOMINION RUBBER COMPANY LIMITED

Circle number 114 on time saver card

In chain—
get choice . . . not chance!



LINK-BELT's complete line gives positive answers to specific design questions

Usual tunnel construction requires that a shaft be bored and lined through bedrock. The Deas Island Tunnel, however, is made up of precast tunnel elements sunk into a trench dredged into the bottom of the Fraser River. This unique method called for the tunnel to be covered with concrete erosion mats and a layer of rock fill. It also required a solution to the problem of laying these mats. Kiewit-Raymond and B. C. Bridge & Dredging Co., Ltd. couldn't take a chance. They called on Link-Belt.

A CHAIN REACTION

Link-Belt engineers responded with SS-102B Class bushed chain. Mats are piled on one side of a barge, pulled off the pile over an adjustable ramp onto the chain conveyor. They go over the side and are laid at approaches to the tunnel 38 feet below. Power transmission is supplied by Link-Belt Roller Chain Drives.

A COMPLETE LINE

Chances are, Link-Belt offers a chain with the exact characteristics demanded by your job. No other single source can equal Link-Belt's broad range of cast, combination, forged and fabricated types plus roller and silent chain.

You can be sure that Link-Belt chain is made to the highest standards. Link-Belt's modern plant facilities assure greater accuracy of manufacture. Exact control of materials and processes give increased uniformity . . . longer chain life.

You can get further facts from your Link-Belt office. Put in a call today.

① **MAT OVERBOARD**—Conveyor consisting of 16 strands of Link-Belt SS-102B bushed chain with special spur attachments makes this method possible. SS Class bushed chain is also ideal for heavy-duty elevator service.

② **DEPENDABLE POWER**—Link-Belt RC 120 roller chain (at left) drives countershaft. Link-Belt RC 160 roller chain drives headshaft at right. Available in single and multiple widths, ¼ to 3-in. pitch.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT LIMITED: Scarboro Plant, General Offices and District Sales—Dept. 859 DE, 1960 Eglinton Avenue E., Scarboro, Ont., Station H, Toronto 13 • Eastern Avenue Plant and Warehouse—731 Eastern Avenue, Toronto 8 • District Sales Offices and Warehouses—Montreal 15: 945 Beaumont Avenue • Vancouver 12: 2550 Boundary Road • Winnipeg 10: 1315 Portage Avenue • Swastika, Ont.: 8 Boisvert Street • Halifax: Austen Bros. Ltd., 118 Hollis Street • District Sales Offices—Edmonton: 10019—103rd Street • Hamilton: 605 James Street, N. • Sydney: Austen Bros. Ltd., 361 George Street • Foundry at Elmira, Ont., 19 Church Street, E. 15,071

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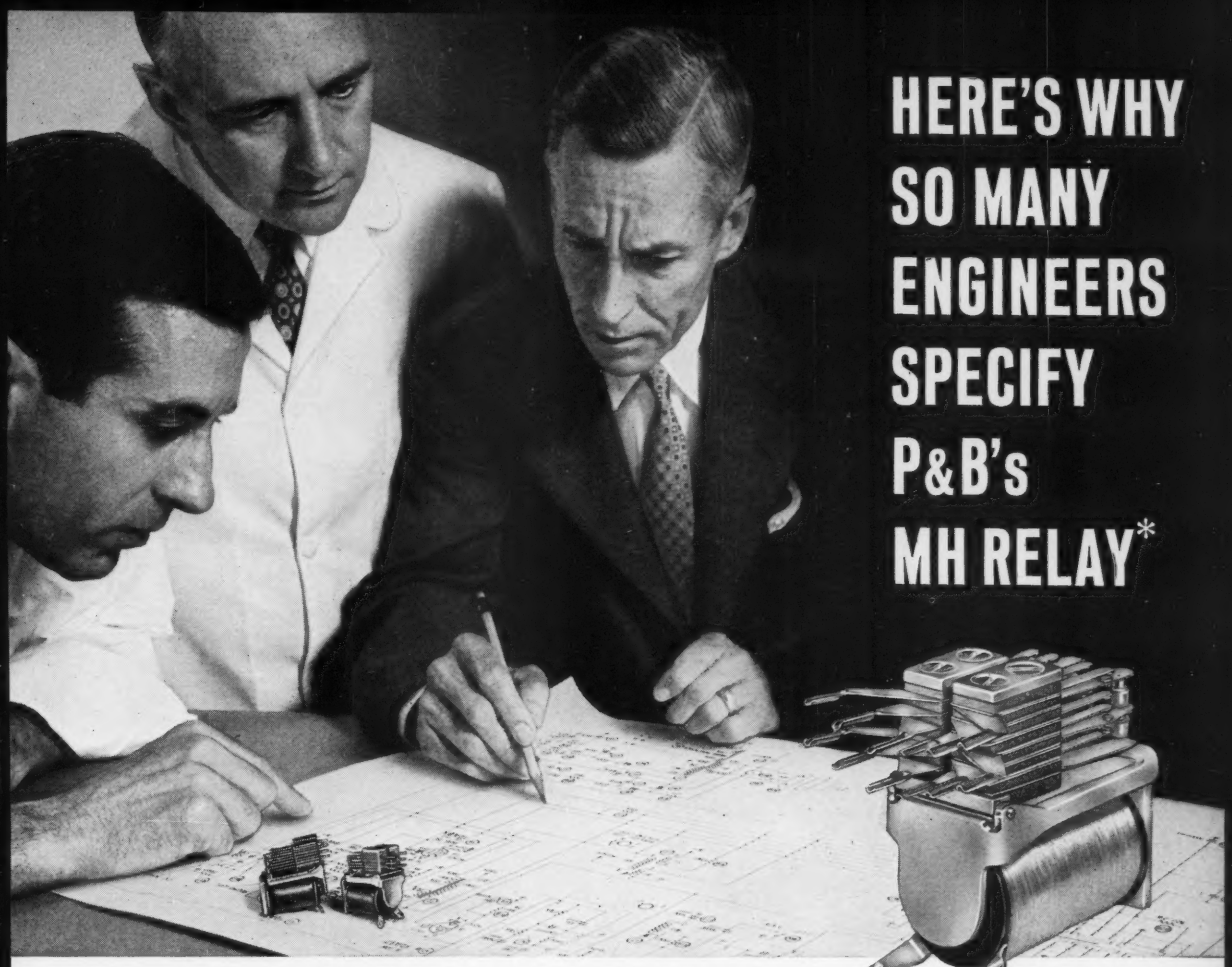


HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW

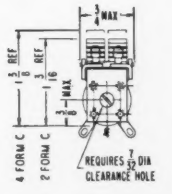
Shown with printed circuit terminals

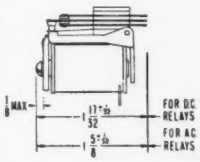
VERSATILITY

and adaptability are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required...when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.





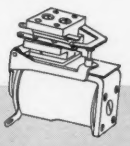
ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.
Insulation Resistance: 100 megohms minimum.
Breakdown Voltage: 500 volts RMS between all elements.
Shock: Up to 30g.
Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.
Ambient Temperature: −45°C. to +85°C. −(65°C. to +125°C. on special order).
Weight: 2½ oz. max. (open relay)
Pull-In: Approx. 75% of nominal voltage.
Pull-In Speed: Approx. 15 ms.
Drop-Out Speed: Approx. 10 ms.
Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

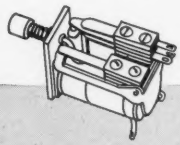
CONTACTS:
Arrangements: Up to 9 springs per stack.
Material: ⅛" silver; also Palladium or gold alloy.
Load: Dry circuits to 5 amps @115V AC resistive.

COILS:
Resistance: 22,000 ohms max.
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.
Current: 2.5 ma to 10 amps DC.

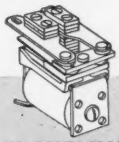
P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



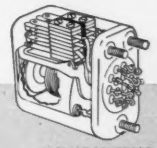
MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



MA LATCHING
Electrical latch; mechanical reset. Small, versatile and offered with selection of contact arrangements.



MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



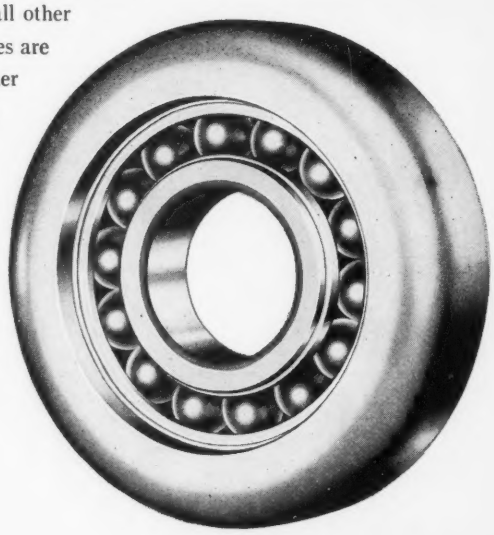
MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

POTTER & BRUMFIELD CANADA LTD.
GUELPH, ONTARIO

For Endurance . . .

It's the NEW HEIM *Unibal*® Ball Bearing

Simplified construction and an entirely new method of ball bearing manufacture represents a great stride forward in anti-friction bearing design. A solid outer race with deep, continuous, unbroken ball groove; and a solid inner raceway with matching ball groove made to fit around a full complement of balls. This eliminates the necessity for loading slots, split raceways, separators, and all other extra and costly assembly devices. The ball grooves are burnished, deep carburized, and hardened. The inner and outer raceways are machined to a smooth finish; the result is quiet, smooth operation, longer bearing life, greater load capacities, and lower costs.

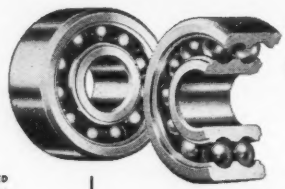


The design possibilities in this new Heim method of construction are almost unlimited. One example is this 4″ heavy duty bearing for high radial and axial load conditions.

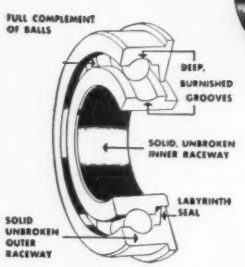
Bearings with plain outer members in small sizes.

. . Medium sizes or sizes to 2″ diameter and over

Bearings with flanged outer members in all sizes



Double row type bearings.



Send for bulletin UBB showing stock sizes and capacities, or ask about special applications.

R&M BEARINGS CANADA LTD.

QUEBEC CITY 755 Blvd. des Capucins · MONTREAL 1006 Mountain St. · WINNIPEG 1302 Notre Dame Ave. · THREE RIVERS 375 St. Georges St.
TORONTO 338 50 Edward St. · VANCOUVER 1066 Seymour St. · LONDON, ONT. 1024 Oxford St. East · HAMILTON 130 Ferguson Ave. N.

FACTORY REPRESENTATIVES AND DISTRIBUTORS FOR CANADA

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DOWN WHERE YOUR SALES BEGIN

If you use copper or copper base alloys in your product, you know how important *quality* is in these metals. It not only helps you keep your production costs down, it can also help you sell—by increasing the efficiency of your product or by lengthening its service life.

Control of quality in Noranda brass mill products begins at the mine. It continues on through smelting, refining, casting, rolling, extruding and other operations. It shows up in your finished product. It is one of the reasons why more and more users in the domestic and overseas markets are turning to Noranda for strip, rod, wire and tube. May we show you how this completely Canadian organization, with its integrated quality control and expert technical service, can help you produce more profitably? Please call us.

COPPER Noranda BRASS LTD.

The key to your best opportunities in metals

Noranda Copper and Brass Limited

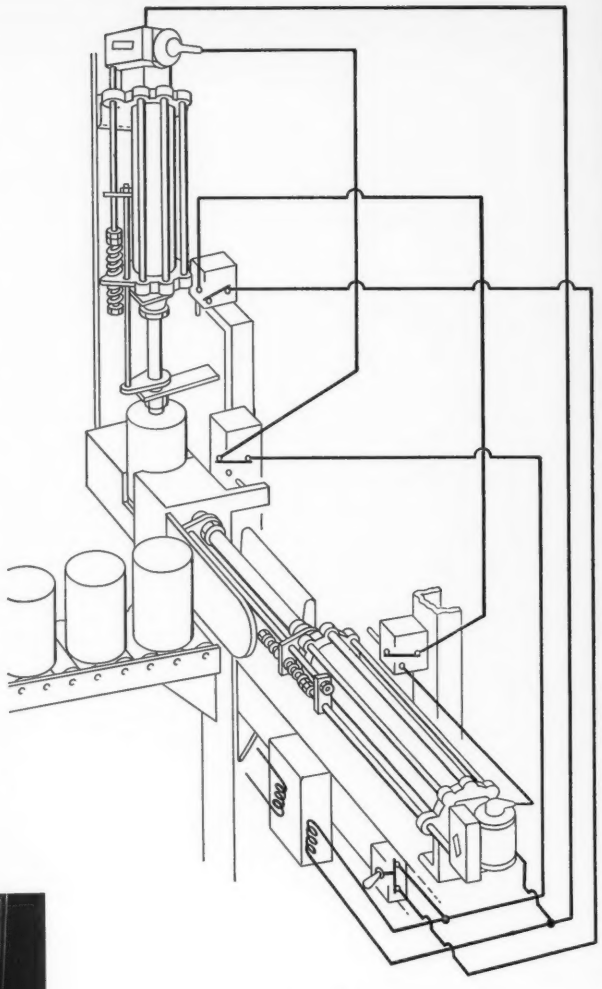
SALES OFFICES: Montreal • Toronto • London • Edmonton • Vancouver

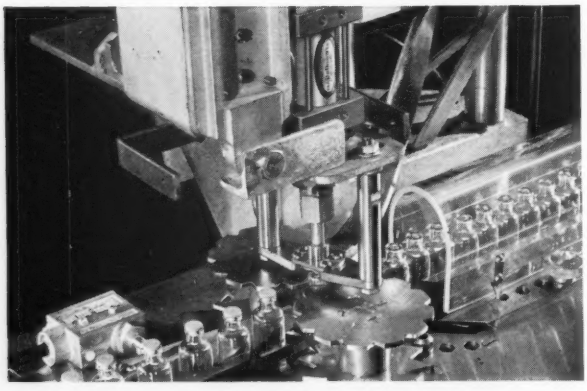
THIS SIMPLE SHOP-BUILT MACHINE SPARKS IDEAS FOR OTHER COST-SAVING UNITS

This SPOT-A-MATION IDEA is another example of how much more simply and economically an operation can be automated using Bellows "Controlled-Air-Power" Devices. The ease of construction and low cost also suggest why these versatile work units have stimulated the imagination and creative ingenuity of cost-conscious men in all types of industries.

Originally designed to punch holes in the bottoms of clay flower pots, this shop-built machine is adaptable to many other operations, such as inserting lids in cans, applying labels, stamping numbers, etc. The two Bellows Air Motors are interlocked to work alternately. A gravity conveyor delivers a clay pot to the first Air Motor, which moves it to a position under the second Air Motor. After the piston rod of the second Air Motor has moved through the work stroke and returned to "up" position, the cycle automatically repeats. This is practical, low-cost automation.

Now, stop a moment and ask yourself a question: "How can I use Bellows "Controlled-Air-Power" to produce more at less cost in *my* plant?"





An adaptation of this SPOT-A-MATION IDEA permitted a drug firm to plug bottles—automatically—four times faster than had been done by two operators. Because sterility was vital, automating the operation with Bellows equipment eliminated the possibility of contamination by human hands.

THIS SPOT-A-MATION IDEA FILE IS YOURS ON REQUEST

Contains installation data, wiring diagrams and equipment lists for scores of Bellows "Controlled-Air-Power" applications, enabling you to automate existing machines or build your own low-cost special-purpose equipment. Write for yours today. No obligation. Address Dept. DE-859, Bellows Pneumatic Devices of Canada, Ltd., Toronto 18, Ontario.

1343B-1

Bellows

PNEUMATIC DEVICES OF CANADA, LTD.

14 Advance Road Toronto, Canada

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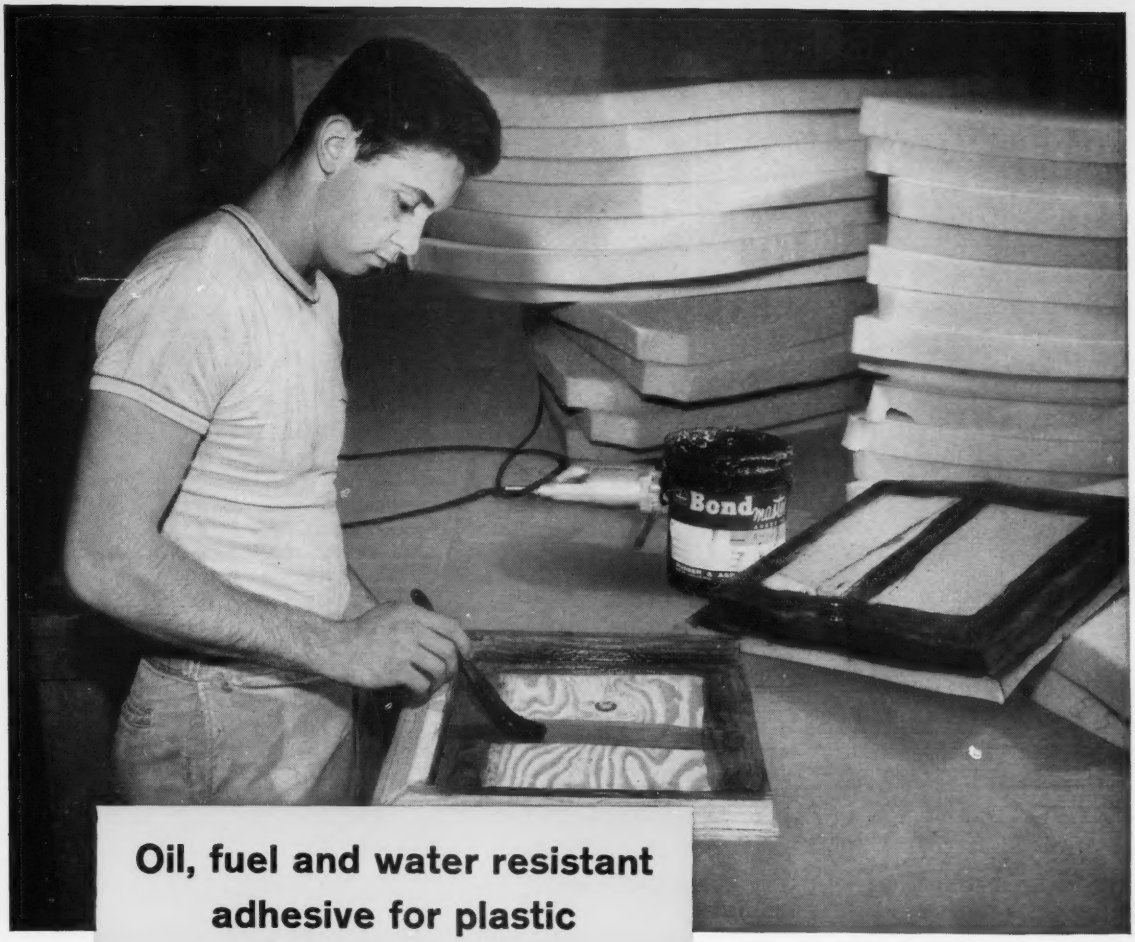

Oil, fuel and water resistant adhesive for plastic foam made with

RCI PHENOLIC RESIN

● The Rubber and Asbestos Corporation of Bloomfield, N. J., uses a Reichhold phenolic resin as an important ingredient in the manufacture of their Bondmaster® G472 liquid adhesive.

Bondmaster G472 is a general purpose adhesive designed for bonding vinyl plastics, nitrile rubbers and cotton duck to metal, wood, concrete and other rigid surfaces.

In one application, illustrated above, the Bondmaster formulation was required to make a strong, sure bond between plastic foam and a wooden chair frame that had to withstand the rigors of marine usage. Bondmaster G472 fitted the job perfectly.

In a recent interview, an R & A formulating chemist said, "The high order of specific adhesion to the plastic foam—which makes Bondmaster the right adhesive for this job—is a direct result of the Reichhold phenolic resin."

Reichhold offers a line of phenolics especially developed for adhesive formulators. And if you're compounding adhesives, remember that RCI is also a major producer of both epoxy resins and PVAc emulsions.

Creative Chemistry . . . Your Partner in Progress

REICHHOLD RCI

REICHHOLD CHEMICALS (CANADA), LTD. • 1919 Wilson Ave., (Weston), Toronto 15, Ontario

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol
Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol

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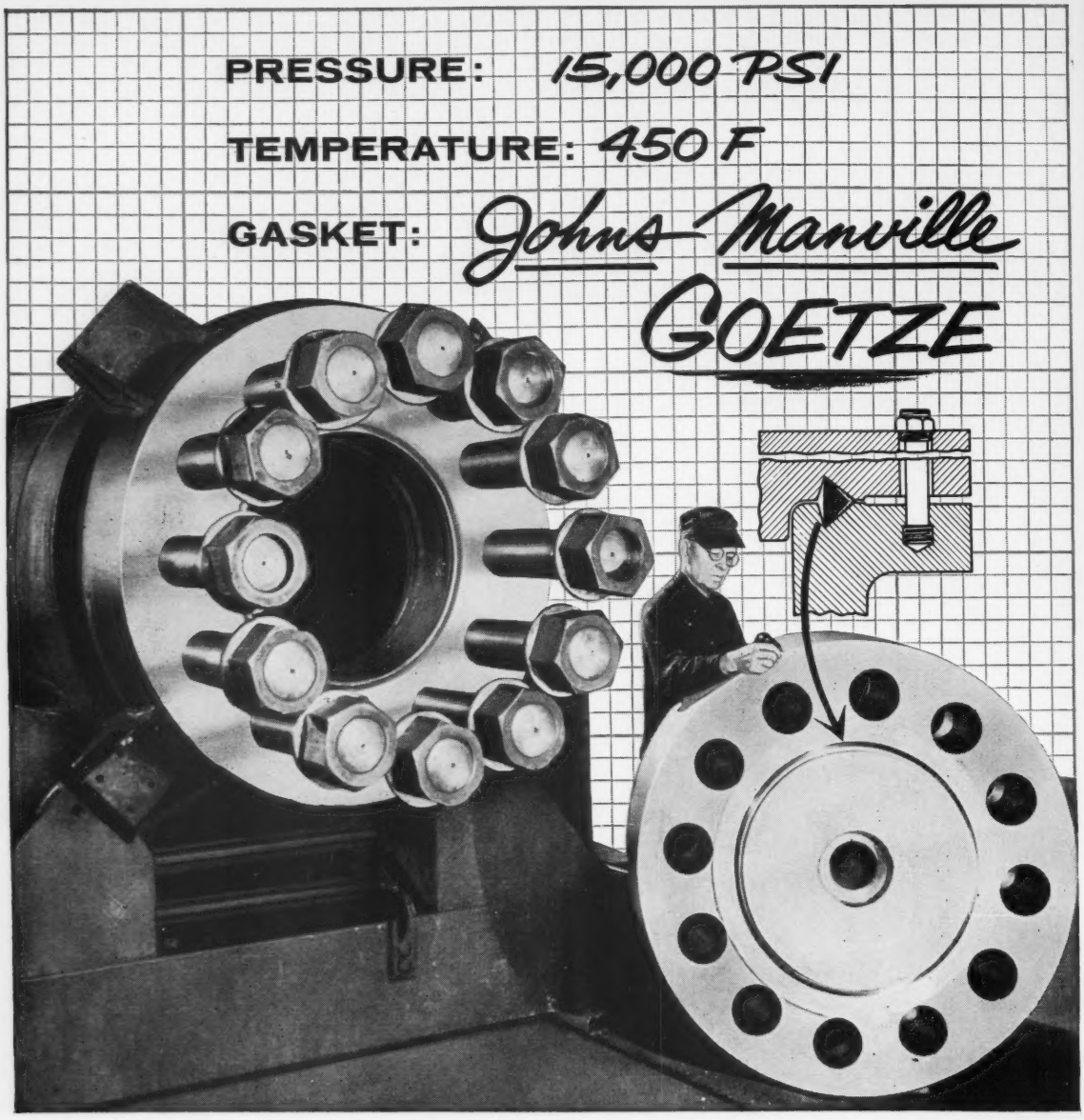

How A. O. Smith maintains tight seals in giant "Multi-Layer" vessels

Today's tremendous pressures and temperatures have placed special demands on manufacturers of processing equipment. A. O. Smith has answered this need with a special type of "Multi-Layer" vessel construction. And Johns-Manville in turn has provided gaskets that assure tight seals under these exacting conditions. Typical of these is the delta type gasket, illustrated above, which was designed, for this application, to withstand pressures up to 15,000 psi. and temperatures to 500 F.

The development of special gaskets to meet special purposes has been the stock in trade of Johns-Manville's Goetze division for more than sixty-five years. Expert technicians possess a knowledge of metals and other factors related to gasket design and performance that is unmatched in the field. What's more, intensive specialization and modern production tooling provide substantial cost savings on J-M gaskets.

If you need gaskets for high pressure vessels for similar applications, send us a drawing or template for quotation. If you have a sealing problem of any kind, J-M technicians will work directly with your own engineers to develop new gaskets —or adapt existing styles—to meet your specific requirements. Write for further information to Canadian Johns-Manville, 565 Lakeshore Road E., Port Credit, Ontario.

I-1055

Johns-Manville PACKINGS & GASKETS

Circle number 109 on time saver card

*Could be 50,000, 100,000, 200,000, or whatever your production run.

You save time and money every time a Speed Nut is tightened. Multiply this saving by the number of fastening operations on your assembly line and the cost reduction is very significant. What's more, improvement in product performance accompanies this cost savings because Speed Nuts provide a *positive* spring tension lock to every fastening.

There are 8,000 different types and sizes of Speed Nuts now in use. If one of these won't cut *your* costs, we'll design one that will.

WITH

DOMINION FASTENERS

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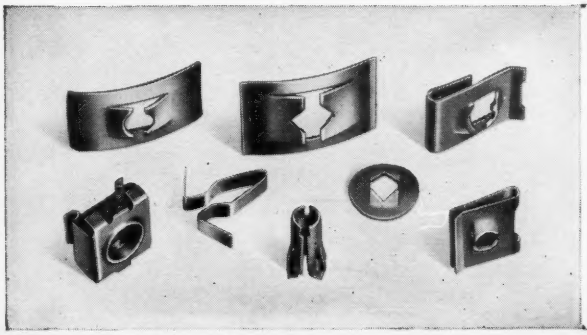

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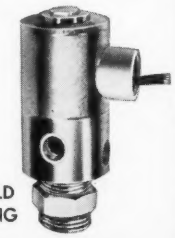

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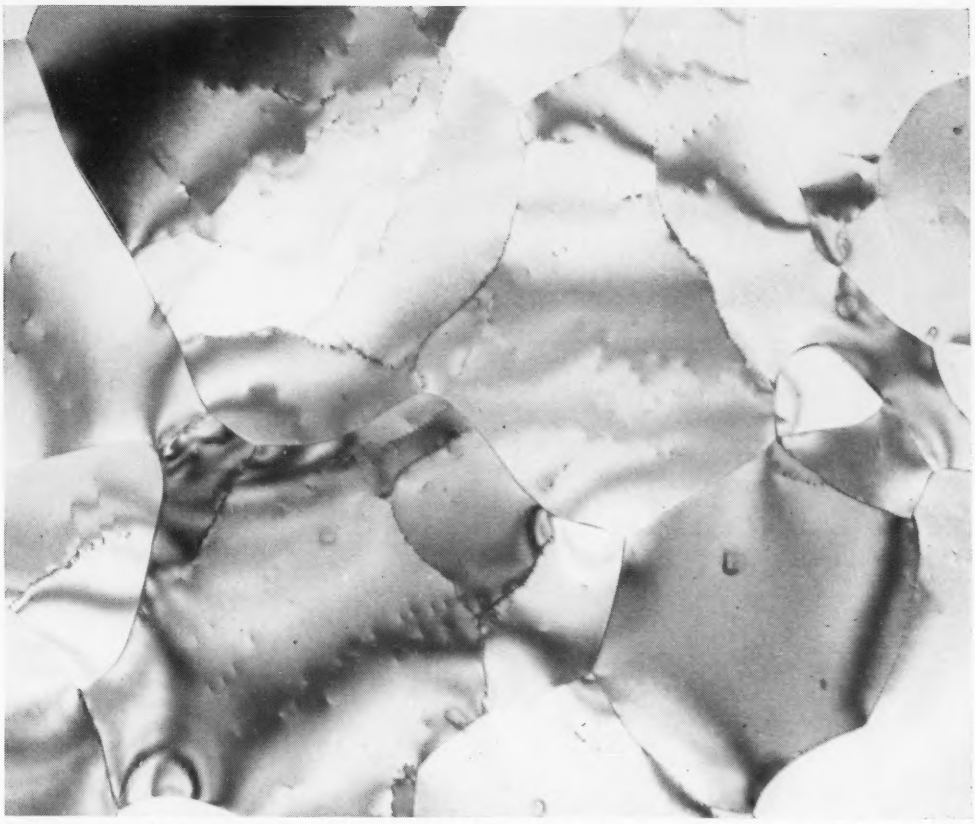


1. Transmission electron micrograph of aluminum foil showing subgrain structure. Magnification x45,000.

Seeing the invisible with electrons

F. W. C. Boswell and **E. Smith**

Many structural features of metals and alloys lie beyond the resolving power of an ordinary metallographic microscope and when the electron microscope became commercially available some years ago there were high hopes that microstructures approaching atomic dimensions could be observed and correlated with mechanical and physical properties. However, since the electron beam is transmitted through the specimen, the latter must be extremely thin and the general approach to electron metallography has been through the use of thin film replicas of polished and etched metal surfaces.

In the early attempts at replication the finest detail that could be reproduced was much larger than the resolving power of the electron microscope and results were often disappointing from a metallurgical viewpoint. Over several years replica techniques were steadily improved both in resolution and reproducibility and considerable new metallurgical information was obtained through application of this method. These techniques are still useful where a simple method is desired for examination of a structure at a useful magnification up to about 25,000X. However, in recent years two new techniques have been evolved which allow the full resolving power of modern electron microscopes — up to 1,000,000X useful magnification — to be applied to the investigation of microstructures. These new

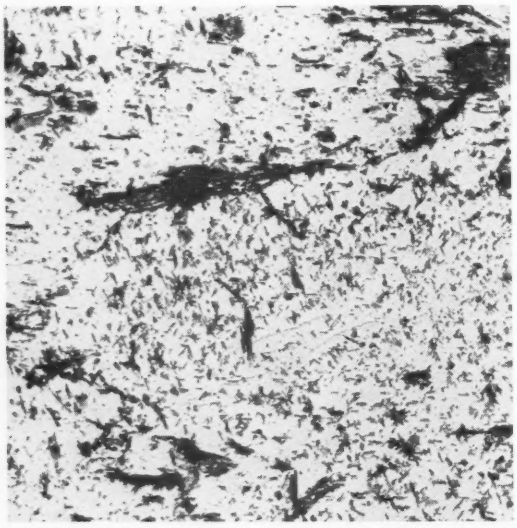
continued

developments are the carbon extraction replica method and the direct transmission electron microscopy of thinned metal foils.

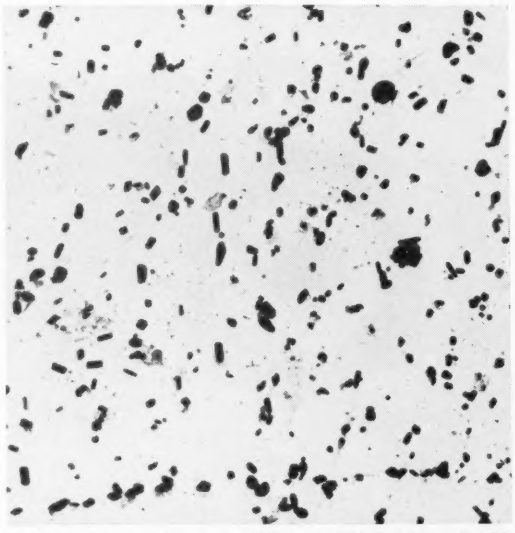
Carbon extraction method

In the carbon extraction replica method a thin carbon film is evaporated in vacuum on to the etched metal surface. This is done by passing a heavy current through pointed carbon electrodes lightly pressed together. The high resistance at the points generates sufficient heat to volatilize some of the carbon. The carbon vapour condenses in the form of a thin, almost structureless film on objects near the carbon rods. The specimen is then placed in the etchant for a second time and the chemical reaction proceeds below the carbon film. Thus the metal matrix is selectively dissolved and the unattacked secondary phases (such as carbides or oxides) are left adhering to the carbon film. The replica is then removed from the surface of the metal, washed, dried and examined in the electron microscope. The method can be used for examination of secondary phases in any alloy provided a suitable selective etchant can be found.

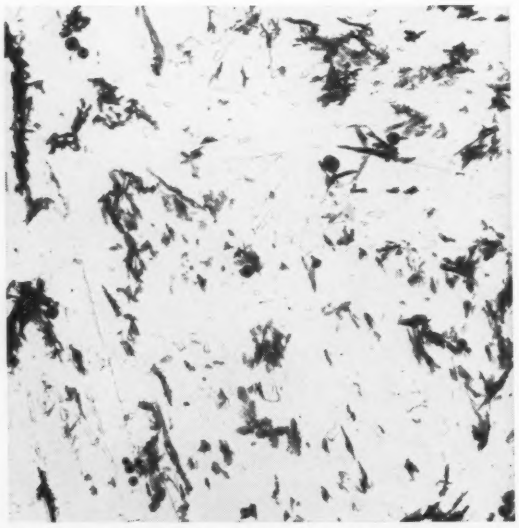
An example of the use of carbon extraction replicas in research is in the study of low-alloy creep-resistant steels. It had been found that many steels containing vanadium had much greater resistance to creep at temperatures up to 600 deg C (1,112 deg F) than those without vanadium. Steels containing vanadium, chrom-



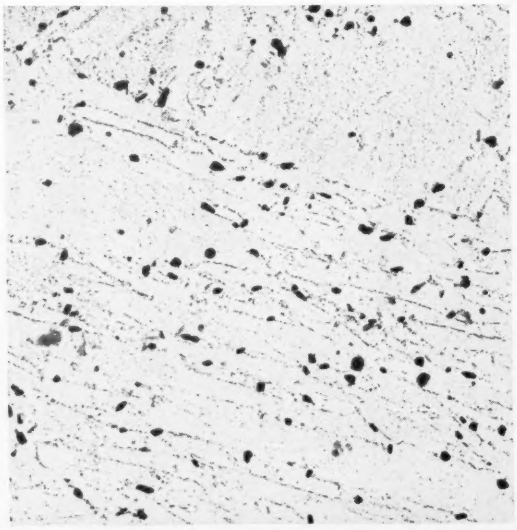
2a. Chromium steel temp. 5 hrs. at 400C. Mag. x8,000.



2b. Chromium steel temp. 5 hrs. at 700C. Mag. x8,000.



2c. Vanadium steel temp. 5 hrs. at 400C. Mag. x8,000.



2d. Vanadium steel temp. 5 hrs. at 700C. Mag. x8,000.

ium and molybdenum in various combinations were quenched and tempered and extraction replicas were prepared for examination in the electron microscope. It was found that the most creep-resistant steels contained a fine precipitate of vanadium carbide, V_4C_3, with particles about 200A in diameter, and that these particles remained small even after severe tempering.

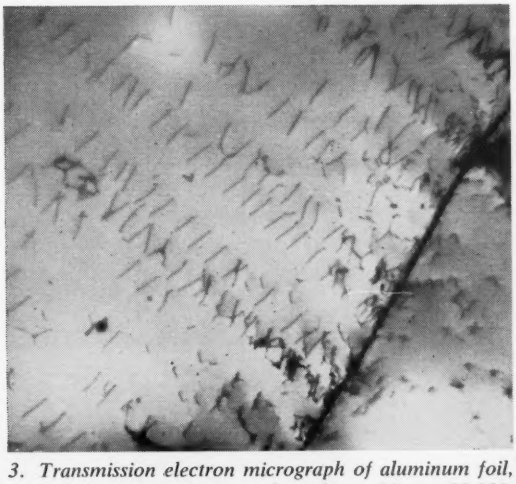
Comparison of steels

Fig. 2 shows micrographs of two steels, one containing chromium and the other vanadium, tempered at 400 deg C (750 deg F) and 700 deg C (1,290 deg F). In both steels the carbide formed at 400 deg C is cementite, Fe_3C, but the particles in the chromium steel (Fig. 2a) are much finer than those in the vanadium steel (Fig. 2c). After tempering at 700 deg C, however, there is a striking change in the microstructures of the two steels. The cementite of the chromium steel has changed to the chromium carbide, Cr_7C_3, which has formed large stick-like particles (Fig. 2b) while in the vanadium steel the cementite has been replaced by a fine precipitate of vanadium carbide (Fig. 2d). The vanadium steel is known to exhibit secondary hardening and the formation of these fine particles of vanadium carbide with simultaneous re-solution of the cementite is responsible for the secondary hardening reaction.

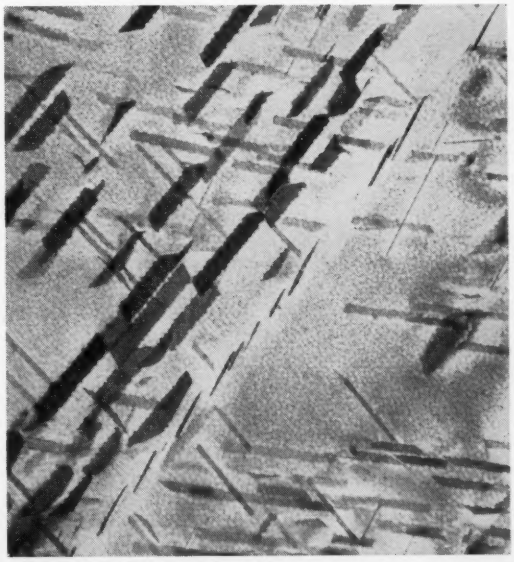
The fact that particles of vanadium carbide grow extremely slowly below 700 deg C is thought to be largely responsible for the high creep resistance of this type of steel. Although it is possible to produce fine particles in both chromium and vanadium steels by suitable tempering, the chromium steel does not maintain its fine structure in service and thus loses its creep resistance in service at 600 deg C (1,112 deg F). The results of this investigation provide a useful guide in the study and design of high-strength, high-temperature alloys.

In the direct transmission electron microscopy of metals a bulk specimen, usually in the form of a foil, is thinned by electrolytic polishing until it will allow penetration by the electron beam. Fig. 4 is a transmission electron micrograph of an aluminum-silver alloy containing platelets of a precipitated phase. The platelets lie along certain crystallographic planes and a grain boundary, containing precipitate particles, can be seen running diagonally across the field. The transmission method thus makes possible the direct observation of secondary phases at various stages of growth. In addition it is possible to detect and study imperfections in metal crystals. Of the various types of imperfections, dislocations play an important fundamental role in determining certain mechanical, physical and chemical properties of metals. Dislocations in stainless steel are shown in Fig. 3. The long, dark line is a grain boundary, and the short, more or less regularly spaced dark lines are dislocations which have moved along a set of slip planes and piled up at the boundary. These dislocations can also form regular surface arrays separating regions of a crystal with slightly different orientations. Fig. 3 is a transmission electron micrograph of thinned, cold-rolled aluminum foil. The boundaries observed are sub-boundaries within a grain and in some cases the dislocation structure of these boundaries can be detected. Individual dislocations can also be seen within some of the sub-grains.

The above examples demonstrate that the full potential resolving power of the electron microscope can now be employed in the study of metallographic microstructures, with the added unforseen advantage that crystal imperfections can also be directly investigated. At the Mines Branch laboratory the extraction replica technique is currently being used in conjunction with other methods for the study of the structure and composition of carbide phases in alloy steels. As part of a general research program on imperfections in crystals, the transmission electron microscopy is being applied to study the distribution and interactions of lattice imperfections and their role in solid state phase transformations. An improved basic understanding of these phenomena should indicate the way for development of materials with improved mechanical and physical properties. ★



3. Transmission electron micrograph of aluminum foil, with dislocation pile-up at boundary. Mag. x18,000.



4. Transmission electron micrograph of aluminum-silver alloy with precipitated phase. Magnification x18,000.

F. W. C. Boswell is Head of Metal Physics Section and E. Smith Scientific Officer, both in Physical Metallurgy Division, Dept. of Mines & Technical Surveys, Ottawa

The simultaneous position detector

Modern die presses have passed the point where a human operator can be considered an adequate monitor. Here is a fool-proof control system

Robert B. Sterns

The high-speed, multiple-die presses coming into use in modern industry require increasingly efficient controls. The higher the operating speed, the greater the chances of mechanical failure and the greater the need for an accurate monitoring system. Even when operating speeds are somewhat lower, as in the cast of die presses with large numbers of dies, accurate monitoring is still essential because the greater the number of cuttings, the greater the possibility of an interruption in the proper operating sequence.

Modern die presses have passed the point where a human operator can be considered an adequate monitor. Even if a trained operator could immediately detect a flaw, he would be unable to push the "stop" button fast enough to prevent damage to a high-speed machine. In most cases, only a fool-proof control system is adequate protection.

This need for protection is common to all multiple-die presses, whether only two dies or as many as 25 or more are involved. In each case this common problem can be solved by controls of similar design but since seldom, if ever, do two presses have identical requirements, the monitor system must be tailored to the requirements of the individual press.

An example of how a basic monitoring principle can be adapted to solve a specific production problem is the "simultaneous position detector" developed for a container company. The company required a system that could provide constant monitoring of a can-forming operation and immediate shutdown when a flaw in the production process was detected.

Author Robert B. Sterns is Director of Engineering of the Sterns Control Corporation, Great Neck, New York.

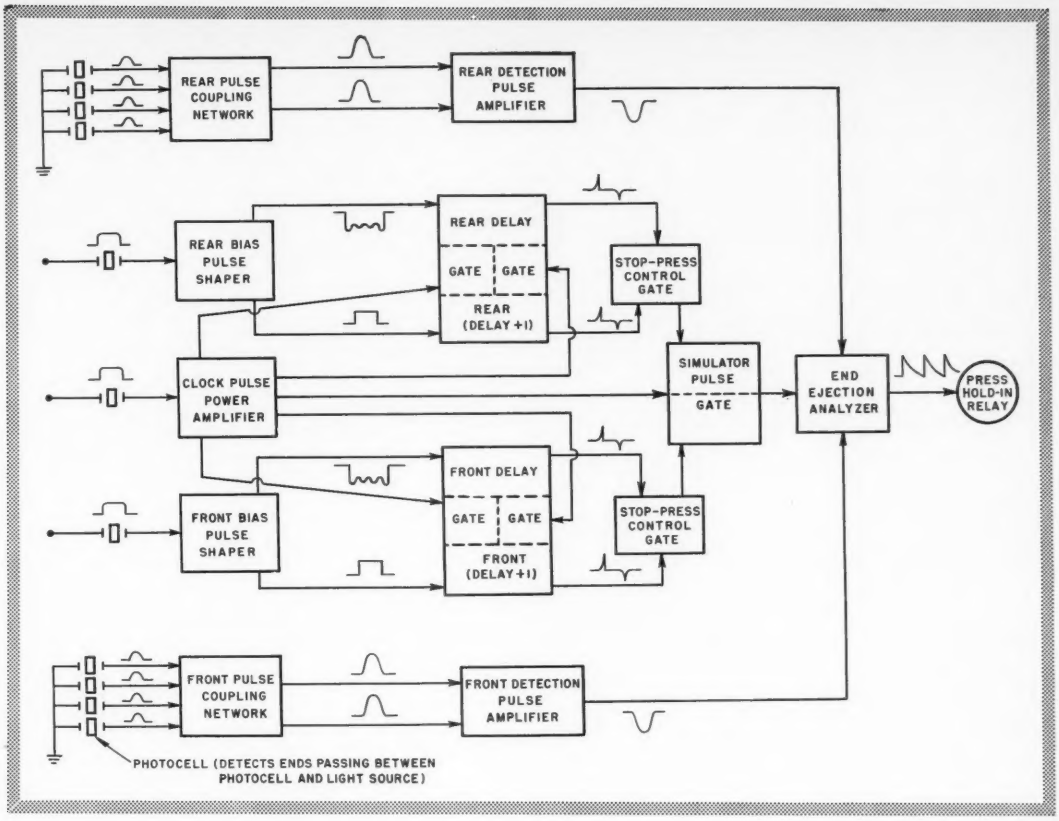
Simple design

The detector that solved this problem is a relatively simple fail safe pulse system, either photo-electrically or magnetically operated in which phasing determines accuracy or inaccuracy. It is applicable to any operation requiring multiple, perfectly-aligned simultaneous signals, and can be adapted to most multiple die-cutting operations. This simultaneous position detector differs from other systems in that it requires each stroke of the press to prove both proper operation of press and control. Any malfunction of either press or control causes immediate shutdown before the next stroke.

The can-forming machinery to which the detector was adapted is a multiple-die press that stamps out can ends from tin plate automatically fed into the die area. The punch is on the crosshead, above a stationary die. Each punch has a "stripper ring" that separates the tin plate skeleton from the formed end, and thus prevents the entire sheet from rising with the punches after the forming is completed.

Can manufacturing operation

The job of the simultaneous position detector is to register the ejection of all can ends formed by each stroke of this machine. It must register the ends that have just been ejected without confusing them either with each other, or with the group immediately following. In other words, the detector must be able to gauge accurately exactly when each stroke takes place, allowing for variations in the machine's operating speed that may range 10% either way. If ejection of any of the ends is not recorded, the detector shuts down the press before the next set of ends can be formed. Immediate



shutdown is essential because ends remaining in a single die will accumulate at a rapid rate.

The detector accomplishes this "fail-safe" monitoring by means of photoelectric registration heads. Each head is responsible for a single end. A key pulse makes it possible for each head to recognize the end for which it is responsible and no other. Each stroke of the die press generates this key pulse by means of a slotted wheel driven by the crankshaft. The slot in the key pulse wheel is set so that it is open to the key pulse photoelectric cell at exactly the time when each end should be passing under the appropriate registration head. The length of the pulse is just long enough to allow each end to pass under its head, taking into account variations in machine speed and ejection time.

Electronically combined

To create an output pulse, the heads on the press are combined electronically with the key pulse system. The output pulse comes through only when all the heads and the key pulse system are perfectly co-ordinated and all ends have been properly accounted for.

This final output pulse, obtained through use of an RC circuit, holds in a relay for about as long as it takes to complete one stroke. If the succeeding pulse does not come through, the relay drops out, signaling the press to stop. This circuit will monitor each stroke whenever and as long as the machine is in actual operation, but only when it is in operation, as there is no static "on but not operating" position for the control.

Auxiliary circuits are included for use whenever the dies have nothing to cut because there is no tin plate below. Photo biasing cells solve this problem. Each cell detects the presence or absence of tin plate passing beneath, and counts the proper number of strokes to allow the sheet to reach the proper position under the dies. In other words, the biasing cells, through accessory circuits, supply artificial pulses whenever necessary to keep the detector from shutting down the machine because no signals have been received, and not because of any failure in the operating sequence. If signals are not received from the amplifier after the substitute pulses are completed, the control shuts down the machine on the next stroke.

High reliability components are used in the detector because of the severe conditions it must withstand in manufacturing plants. Functional plug-in circuits make it possible for plant maintenance men to isolate any trouble and make rapid repairs.

The combination of pulse and digital circuits makes this relatively simple and foolproof system adaptable to the control and monitoring of complex machines. With this system, highly accurate sequencing of machine operation is possible at a cost lower than that involved when control is accomplished by mechanical means. In addition, the system has the feature of being able to detect its own malfunction. ★

What your professionalism is worth

If you're after a fatter pay cheque — then develop your executive talent

Eric Haworth *Assistant Editor*

During World War II, all persons with professional status (including engineering) were required to enrol in the Scientific and Technical Personnel Register of the Canadian Department of Labour. This was to make the equitable allocation of our nation's scientific and technical manpower less of a nightmarish job.

The information proved to be of great value in establishing and maintaining constant checks on this vital segment of the labor force. With peace came decontrols, and mandatory enrolment could not be continued. But the register was, and is, maintained on a voluntary basis with the assistance of universities and professional associations. (Registration is confined to persons with a university or equivalent degree).

A system has now been evolved whereby one third of the register is surveyed each year. The information contained in the tables is the result of the 1958 (and thus most recent) sampling. The preliminary report covers nearly 11,000 persons in engineering, architecture and allied sciences. Engineers are the largest group —comprising 55% of the total.

TABLE 1
Median Salaries of Engineers and Scientists by Year of Bachelor Graduation and Level of Education, 1957

Year of Bachelor Graduation	Engineers—Level of Education		
	Number	Bachelor's without Postgrad. Training	Master's and Doctor's
Before 1915	60	$ 9,010	$ —*
1915–1919	37	10,550	(10,450)
1920–1924	233	10,605	8,850
1925–1929	257	10,130	9,575
1930–1932	181	9,760	8,950
1933–1934	191	10,535	7,950
1935–1936	172	9,835	9,280
1937–1938	188	9,800	10,250
1939–1940	196	9,605	8,750
1941–1942	219	9,225	9,280
1943–1944	219	8,665	8,500
1945–1946	244	8,290	8,500
1947–1948	448	7,895	7,700
1949–1950	889	7,410	7,735
1951	326	6,865	6,880
1952	114	6,525	6,750
1953	202	6,295	5,735
1955	179	5,580	—*
1956	234	5,180	—*
1957	45	4,630	—*
Net Total	4,634		
Not Included	1,281(1)		
Total	5,915		

* 1–4 cases.
( ) 5–9 cases.
(1) This is made up of 538 who worked either part-time or less than 10 months during the year; 428, including 48 non-graduates who supplied no salary information; seven 1954 graduates; and 308 non-graduates who did supply salary information.

TABLE 2
Median Salaries of Engineers by Function, Level of Education, and Year of Bachelor Graduation, 1957

Education and Year of Bachelor Graduation	Number	Function(1)					
		Research and Development	Des. and Draft.	Testing, Insp. and Lab. Services	Production Operation, etc.	Supervision	Admin. Management and Exec.
Bachelor's without Postgraduate Training							
Before 1918	78	$(9,280)	$7,280	$ —*	$7,615	$8,450	$12,450
1918–1927	355	8,780	6,880	—*	8,950	8,830	13,700
1928–1937	655	7,910	7,665	7,150	9,090	9,240	12,540
1938–1947	1,034	7,755	7,590	7,805	7,875	8,710	10,515
1948–1957	2,115	6,360	6,195	6,325	7,440	7,200	8,635
Master's and Doctor's							
Before 1918	7	—*	—*	—*	—*	—*	—*
1918–1927	35	—*	—*	—*	—*	(8,700)	15,450
1928–1937	96	(8,950)	7,575	(6,780)	—*	11,115	12,450
1938–1947	118	8,225	(8,950)	—*	—*	8,450	10,280
1948–1957	148	7,215	6,880	(6,700)	6,950	8,325	8,615
Net Total	4,641(2)						
Not Included	1,274(3)						
Total	5,915						

*) 1–4 cases.
( ) 5–9 cases.
(1) "Production, operation, etc." includes installation, erection, maintenance, layout and location, field exploration and construction. "Supervision" includes supervision of department, district, floor, section. "Other" includes writing, information services, library work, patents, personnel and safety, finance, budgetary control and other.
(2) Includes seven 1954 graduates.
(3) This is made up of 538 who worked either part-time or less than 10 months during the year; 428 who did not supply salary information, including 48 non-graduates; and 308 non-graduates who did supply salary information.

Some executives earn double that of colleagues graduating in same year

Because this report is concerned with the role of engineers in Research and Development, we have isolated it from information about scientific personnel. The tables tell an interesting story. Table I shows that in this category there is no great gap in remuneration between the engineer with a bachelor degree and one with a doctorate. The 1920-24 bachelor graduates hit the pay cheque jackpot. But riding hard on their tails are 1937-38 engineers with masters and doctorates who take a mere $350 per annum less.

In Table 2 we get down to more detail and discover that industry is the most generous boss to work for. In some instances the university-employed engineer is limping behind his industrial counterpart by up to $3,500 per annum. No figures are available in this group for federal govt., high schools, technical and commercial school employed engineers.

Industry not only pays more for its engineers, but bestows greater rewards on those with particular experience. Way out ahead are engineers with executive ability. In one bracket, the executive-type engineer earns twice as much as his designing and drafting colleague who graduated in the same year. Again, the pattern shows through — unless you're in the 30-40 years' experience group — the difference in salary between bachelor and higher degree graduates is not substantial. In fact there is no apparent emphasis on the greater studies involved — from the salary end. (The case is arbitrary, as in some groups a bachelor is making more money than his better-qualified counterpart; in other groups greater specialization wins out to the tune of $1,500 per annum more).

Summarizing, these tables show that the top money is being earned by bachelor status engineers with up to 40 years' experience, and presently holding executive jobs. But the "young whippersnappers" with 20 years' less experience are the next closest group. At the present time, an engineer's best friend is his executive ability — that is, if he has a yen for a better-than-average pay cheque. As most engineers' wives have. ★

Industry is the most generous boss to work for—bestows greater rewards on engineers with particular experience.

TABLE 3
Median Salaries of Engineers by Type of Employer, Level of Education and Year of Bachelor Graduation, 1957

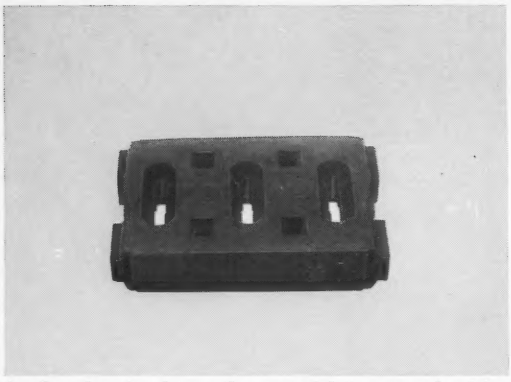
Education and Year of Bachelor Grad.	Number	Type of Employer			
		Industry	University	Prov. and Municpl. Govts.	High/Tech/ Comm/Schools
Bachelor's and Bachelor's with some Postgrad. Training					
Before 1918	78	$ 9,865	$ —*	$8,700	—
1918–1927	355	11,450	(8,450)	8,075	—
1928–1937	655	10,405	—*	8,130	*
1938–1947	1,034	9,020	—*	7,040	—
1948–1957	2,115	6,925	5,590	6,020	—
Master's and Doctor's					
Before 1918	7	—*	—*	—*	—
1918–1927	35	10,950	(7,450)	—*	—
1928–1937	96	10,530	7,950	(8,200)	—
1938–1947	118	9,405	7,350	(8,280)	—
1948–1957	148	7,700	5,615	(6,450)	—
Net Total	4,641(1)				
Not Included	1,274(2)				
Total	5,915				

TABLE 4
Sex and Function of Engineers and Scientists, 1957

Function(1)	Number	Sex			
		Male Number	%	Female Number	%
ENGINEERS	5,915	5,904	99.8	11	0.2
Research and Development	561	560	99.8	1	0.2
Designing and Draughting	535	533	99.6	2	0.4
Testing, Inspection, Laboratory Service	163	163	100.0	—	—
Production, Operation, etc.	1,296	1,294	99.8	2	0.2
Supervision	1,023	1,023	100.0	—	—
Administrative, Management and Executive	1,368	1,367	99.9	1	0.1
Teaching, Instructing, and Extension Work	125	124	99.2	1	0.8
Purchasing, Marketing, Sales and Service	392	392	100.0	—	—
Consulting and Private Practice	325	324	99.7	1	0.3
Other	127	124	97.6	3	2.4

Function(1)	Number	Sex			
		Male Number	%	Female Number	%
SCIENTISTS	4,050	3,899	96.3	151	3.7
Research and Development	1,101	1,041	94.6	60	5.4
Designing and Draughting	22	22	100.0	—	—
Testing, Inspection, Laboratory Service	272	236	86.8	36	13.2
Production, Operation, etc.	565	561	99.3	4	0.7
Supervision	489	486	99.4	3	0.6
Administrative, Management and Executive	569	568	99.8	1	0.2
Teaching, Instructing, and Extension Work	598	561	93.8	37	6.2
Purchasing, Marketing, Sales and Service	196	194	99.0	2	1.0
Consulting and Private Practice	104	103	99.0	1	1.0
Other	123	116	94.3	7	5.7
Net Total	9,965	9,803	98.4	162	1.6
Not Included	830(2)				
Total	10,795				

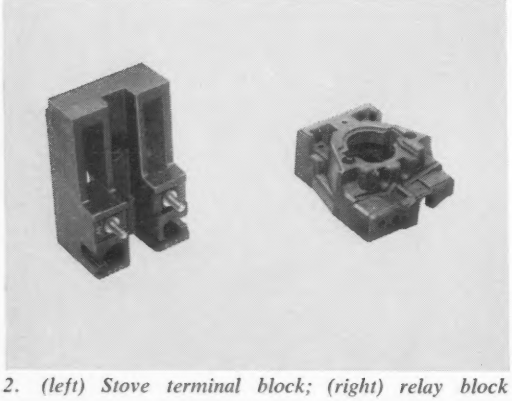
(1) "Production, Operation, etc." includes installation, erection, maintenance, layout and location, field exploration, and construction, "Supervision" includes supervision of department, district, floor, section. "Other" includes writing, information services, library work, patents, personnel and safety, finance, accounting, budgetary control.
(2) Of 830 not included, 443 are in Architecture, 263 in Veterinary Medicine and 124 in other scientific and technical fields.



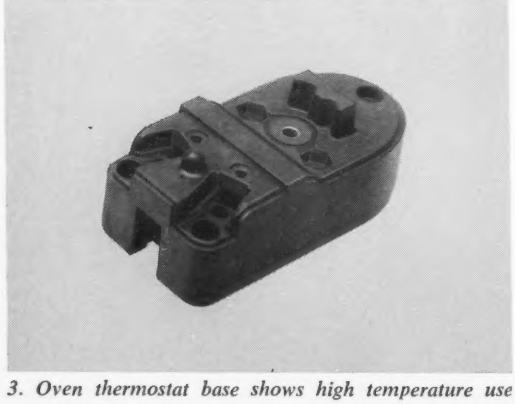
1. Bus bar insulator: the material is noncarbonizing

Made-to-order plastic moldings

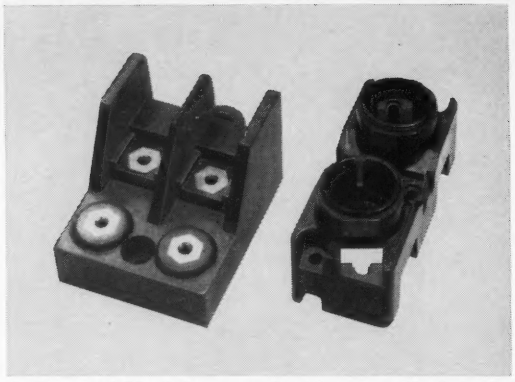
A stone-like molding compound known as Rosite is a very suitable material for electrical applications. Its properties include: basic resistance to heat; inherent arc-quenching capability; nontracking characteristics; high dimensional stability. In addition, by devising new molding methods, the Rostone Corporation has been able to mold it into the complex shapes required for electrical parts. Typical applications are shown here.



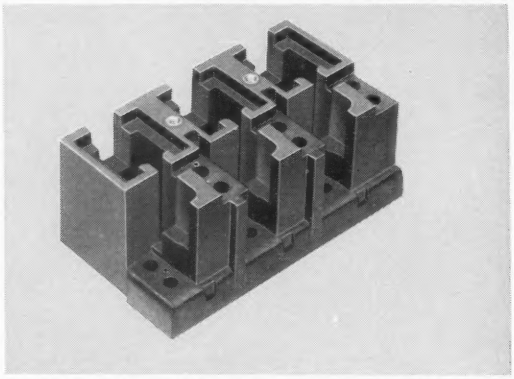
2. (left) Stove terminal block; (right) relay block



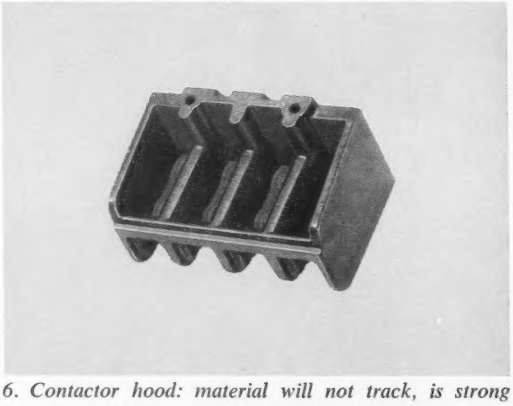
3. Oven thermostat base shows high temperature use



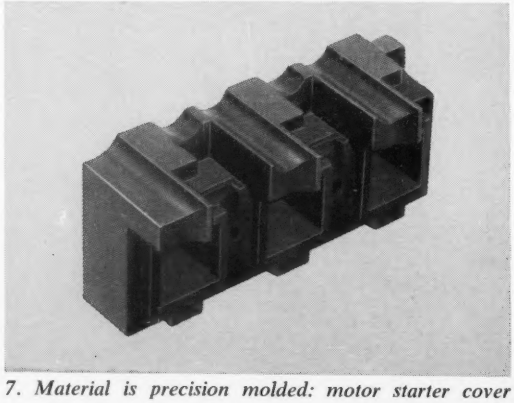
4. Terminal block is grouped with a fuse block (right)



5. Material is used in arcing zones: motor starter base

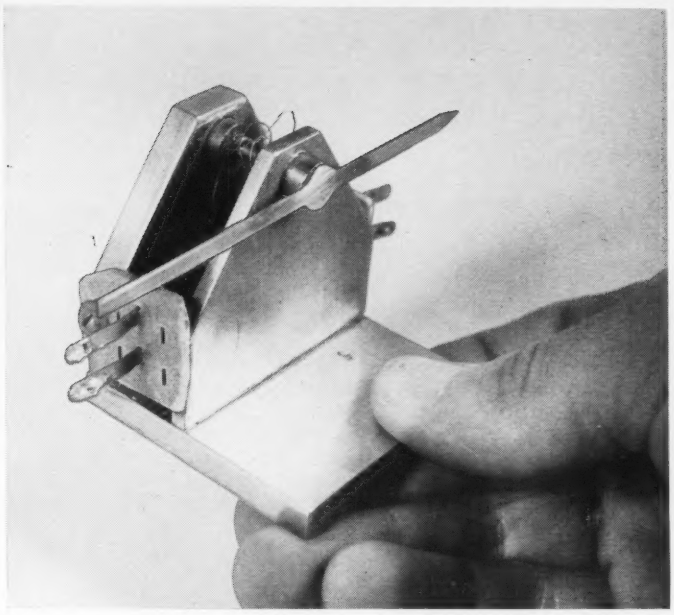


6. Contactor hood: material will not track, is strong



7. Material is precision molded: motor starter cover

Torsional transducer



Semiconductors for measuring torque

Extreme conditions apart, semiconductors vie for the ideal gauge title

The conversion of mechanical motion into an electrical signal is, of course, a fundamental feature of the telephone and any other microphone-like device. Mechanical motion of a diaphragm (or some vibrating material) results in a fluctuating current. The microphone is only one of the many mechanical-electrical converters or transducers. Others are used in phonograph pickups, and in gauges for measuring tension, compression and torque (to quote a few).

This article deals particularly with the measurement of torque, since certain semiconductors (hitherto used chiefly for transistors and diodes) have a number of remarkable properties when used in gauges. Before discussing these semiconductors specifically, however, it is helpful to gain perspective by reviewing briefly some of the problems of this branch of mechanics.

Of the many materials that can be used as electro-mechanical transducers, the two most important groups are the piezo-electric materials (in which mechanical motion produces a voltage) and the piezo-resistive materials (wherein mechanical motion produces a change in resistance). Magneto-strictive materials (wherein a mechanical motion causes a change in a magnetic field, which then generates a voltage in a surrounding coil) are another possibility, but these have certain disadvantages that limit their use in many applications. The voltage generated in a magneto-strictive device is proportional to the time rate-of-change of the magnetic field. The generated voltage is thus proportional to the velocity of displacement, rather than to the actual displacement. Furthermore, magneto-strictive materials are subject to eddy-current losses at moderate and high frequencies, which alter the relationship between velocity and voltage. These materials are thus at a disadvantage for measuring force, torque or acceleration.

The ideal would be a device that is very sensitive to small forces; responsive to both static and periodic forces over a wide band of frequencies; operative over a wide range of temperature and humidity; and stable with time. It would be better, too, for the device to be easily fabricated and small enough to add only negligible weight to the object being measured.

In general, piezo-electrics, like quartz and ADP (ammonium dihydrogen phosphate), perform well at high frequencies but are inadequate for static or low-frequency forces, because leakage current masks the response. In addition, they lose effectiveness at high temperatures and high humidities. Also among piezo-electrics, the newer ferro-electric ceramics (like barium titanate) have better temperature and humidity characteristics, and also have the advantage that they can be formed into irregular shapes. They tend, however, to change with time, and may depolarize under high stress.

There is much need, therefore, for more stable and more sensitive materials to operate over wider ranges of frequency, temperature and humidity. Semiconductors have most of these advantages.

Many metals and alloys exhibit a change in resistance with strain, and a length of metal wire (usually constantan) is the sensing element in the most common types of strain gauge.

Most metal-wire strain gauges have gauge factors between 2 and 4. Somewhat higher values are obtained with platinum wire, and values up to 20 are noted for nickel. By contrast, germanium is so much more sensitive that gauges using it have factors up to 150, whilst

continued ▶

silicon permits factors as high as 175. Geyling and Forst (of the Bell Laboratories) have used germanium for a displacement gauge so sensitive that the factor limiting the sensitivity is the normal vibrations of a building. A shunt resistance had to be placed across the germanium to eliminate the effect of these vibrations, after which the device was still about fourteen times as sensitive as the usual wire-type gauge. With mounts that are resistant to shock and vibration, the full sensitivity (about eighty times that of a wire gauge) can be realized.

Thus, germanium, silicon and other semiconductors permit strain gauges that are far more sensitive than older types. But this is merely one of their advantages. Equally important for many applications is the fact that semiconductors can measure static and low-frequency stresses, as well as higher-frequency stresses up to the resonant frequency of the material.

These semiconductor crystals have another advantage not possessed by wire-type gauges: they respond to torsional and shearing forces, and thus can be used directly to measure torque. R. N. Thurston has constructed a torsional transducer. This is a cylindrical crystal of germanium cemented to a solid support at one end, with electrodes (numbered 1 to 6) attached as shown in fig. 2. With proper biasing voltage, current is caused to flow from electrode 3 to electrode 5 and from electrode 6 to electrode 4. Electrodes 1 and 2 (attached midway along the cylinder) are normally at neutral positions, but when torque is applied to the free end of the cylinder, a voltage is generated across them. This voltage is directly proportional to the torque, and so no balancing bridge is required. Besides its sensitivity, this transducer has the advantage that it responds to both steady-state and alternating torque, and that the angular displacement is negligible.

The device uses a cylinder of germanium, 0.130 in. diameter and 0.50 in. long. The graph (fig. 1) is a calibration in terms of voltage generated across electrodes 1 and 2 with various amounts of torque, for three different values of biasing current.

In experimental work, crystals were prepared and cut so that their unstrained resistance was 55 ohms, the same resistance as that of a common wire-type element. Thus, the same bridge circuit and other associated equipment could be used, merely by substituting the new gauges. These advantages mean that semiconductors have nearly all the qualities needed for an ideal gauge. There are still extreme conditions for which no simple measurement device is adequate, but the new gauges offer such greatly expanded characteristics that research, development and testing groups are sure to find many uses for them.

There is another interesting aspect to these gauges: they are a good example of how pure research often results in useful (and sometimes unexpected) by-products. Extensive physical and chemical research has been conducted on the properties of semiconductors, which was the reason the piezo-resistance effect was measured. This research has resulted in a useful device for an entirely different field. ★

This article has been written from information supplied by the Bell Telephone Co. Laboratories, New York.

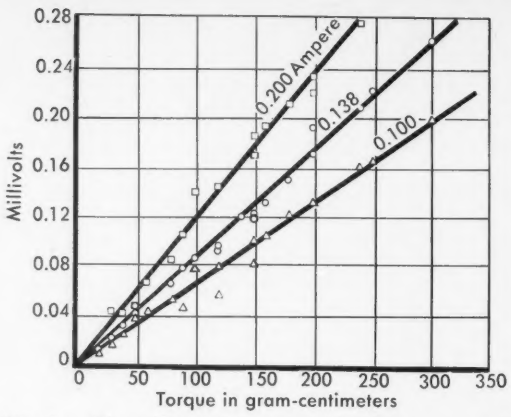


Fig. 1 — The calibration in terms of voltage generated is shown for three different values of biasing current.

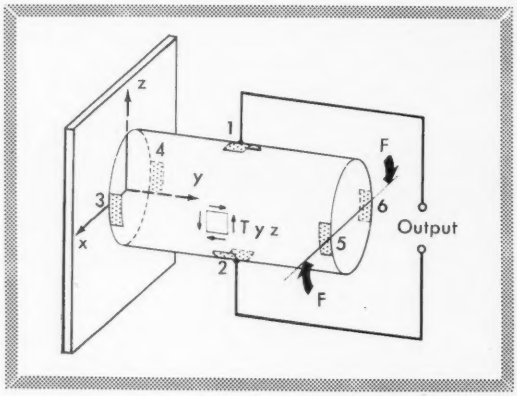
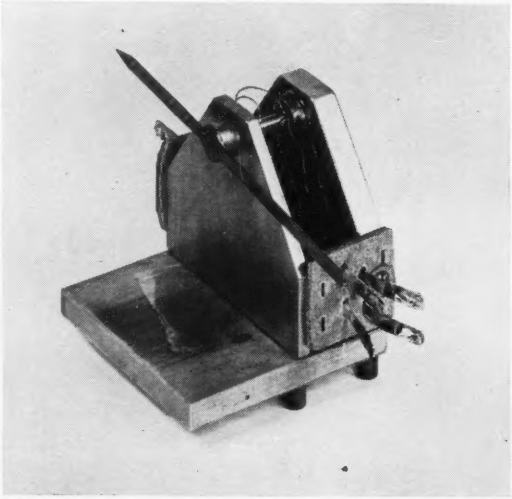


Fig. 2 — Housed in cylindrical germanium crystal, arrangement of electrodes permits torque measurement.



The torsional transducer. Torque is applied to arm on free end of crystal: other end is cemented to back plate.

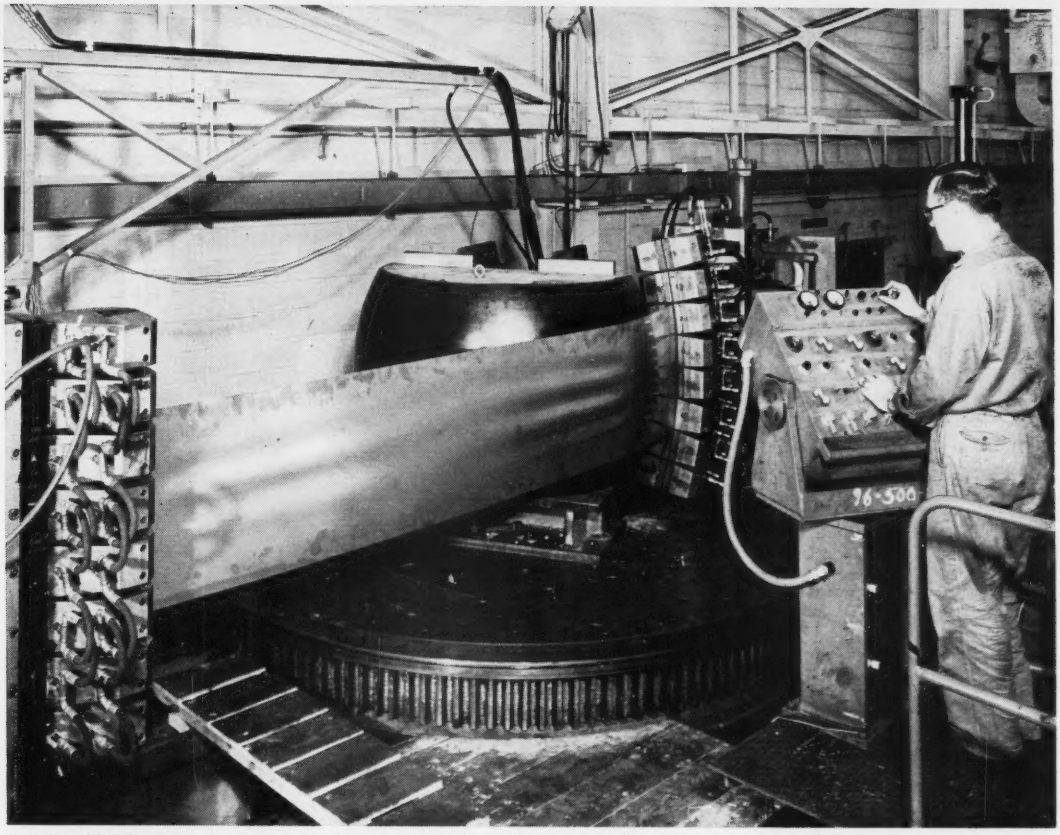


Fig. 1—Yield point of metal and guidance of machine during stretching operation is made automatically with relay.

The principles of contact meter-relays

These devices have characteristics that simplify electronic circuits

Two models of meter-relays as described in this article have recently found application in Canadian designs.

Canadian Marconi Company used the Model 255-C in micro-wave radio relay equipment. It monitors the standing wave ratio and in the event of the VSWR ratio exceeding the preset limit it will automatically institute change over action to standby equipment. At the same time the meter gives an indication at all times of the actual current, which is an indicator of the VSWR during transmission.

A Model 137 non-indicating meter relay is a miniature plug in unit used by Mechron Engineering in equipment designed and built for use on the Mid-Canada Line. It has a double limit and is set to monitor a nominal 230 volt generating system for either under or over voltage. The relay initiates change-over action to a second generating set, if required.

Glenn Krebs

Contact meter-relays are distinctive electro-mechanical devices that have no real counterparts. They perform a combination of functions that might otherwise require several separate instruments. Because they can indicate, monitor and control any variable that can be measured electrically, they are unusually versatile components for design engineers.

The most sensitive of all electromagnetic relays, a meter-relay may be actuated by a direct signal as small as 0.2-microampere. A direct signal may come from any of the common transducers, such as photo cells, thermocouples, tachometer generators or thermistors. With very simple amplification, signals from strain gauges or differential transformers may be used. Another very important application is in Wheatstone bridges.

The meter-relay has a permanent-magnet, moving coil (D'Arsonval) movement, with a meter dial on which signal strength is continually indicated. At the same time, the meter-relay functions like a control

continued ▶

relay, triggering whatever action is desired when the signal rises or falls to present points. These set points may be adjusted simply and easily over a wide range.

Since the meter-relay operates on only a few microwatts, while working into circuits requiring much more power, it has the further advantage of serving as a simple, efficient amplifier with a power gain that is frequently surprising.

In the last few years, the meter-relay has become even more important in the design field because it has been found to have certain inherent characteristics that stabilize and simplify electronic circuits. A meter-relay will do a number of things—easily and inexpensively. Once calibrated, it offers a stable scale of values against which signals may be checked. Normal calibration accuracy is 2 per cent, but repeatability of the set points is 0.25 per cent or better. The differential between the signal that will leave the contacts open and the signal that will close them is less than 1 per cent.

The meter-relay principle

In the D'Arsonval movement of a meter-relay, current passes through a coil suspended on jeweled pivots in the field of a permanent magnet. Restrained by some force, usually hair-springs, the coil rotates in proportion to the amount of current. The basic idea of a meter-relay involves mounting a contact on the pointer carried by the moving coil, with a mating contact positioned inside the meter. Usually the second contact is fastened to another pointer, which can be adjusted, or to a fixed stud or pin. When the signal current rises or falls to the point marked by a fixed contact a circuit is closed across the contacts. Through slave relays, this circuit usually works into one carrying much greater current and desired action takes place.

There are two general types of contacts in meter-relays: locking and non-locking. The locking category is further split into locking coil and magnetic types. It is generally agreed that the locking coil type (fig. 2) is the most reliable and that it assures the most positive control action. The locking feature involves some limitations, but these are a small price to pay for the added reliability. Another important advantage of the locking coil is longer contact life.

By itself, the moving coil of a meter-relay exerts only a few milligrams pressure between the contacts. Such a non-locking arrangement is unreliable because it frequently leads to sticking of contacts when the signal is removed. Reasons for this problem include arcing, mechanical wear and natural adhesion between two pieces of metal.

In general, therefore, non-locking meter-relays are usually restricted to applications where (1) the signal abruptly rises above and falls below the point-of-contact (2) contact load is less than 10 microamperes (3) open-circuit voltage is less than 10 volts and (4) a high torque (1 milliampere or better) meter movement is used. Even under these conditions, non-locking contacts generally will have a limited life of not much more than 100,000 operations.

Locking contacts may be expected to last between 10 and 20 million cycles, if properly rated. The most successful design for locking action involves an extra coil wound on the moving coil. This locking coil is connected to the contact carried on the moving pointer and to a dc (or rectified ac) source in series with the load. Thus, when the contacts close, current through them also flows through the locking coil.

Even though there may be high contact resistance at the instant of contact, the small current in the locking coil increases pressure, starting to break down this resistance. As the resistance goes down, the current goes up until the full current in the locking gives high locking torque and positive contact. This process is almost instantaneous. Without the locking coil, pressure is no more than 5 milligrams; with the locking coil, pressure is from 1 to 3 grams.

In the design illustrated in fig. 3, the locking torque also loads the spring on which the adjustable contact is amounted. When the current flow through the locking coil is finally interrupted, the loaded spring snaps the contacts apart and sticking is prevented. This action has a unique wiping and self-cleaning quality that is not achieved by any other design of meter-relay.

In the magnetic type of locking meter-relay, small permanent magnets are the fixed contacts. This has the advantage of pulling either ac or dc through the contacts. They will also stay locked until reset, even if no current flows through the contacts. On the other hand, the scale arc of the magnetic locking meter-relay is limited, usually to about 20 degrees—compared to the 95 degrees or so of other types.

Meter-relay specifications

Meter-relays are furnished in ranges from 0 to 5 microamperes to 0 to 50 amperes, or 0 to 5 millivolts

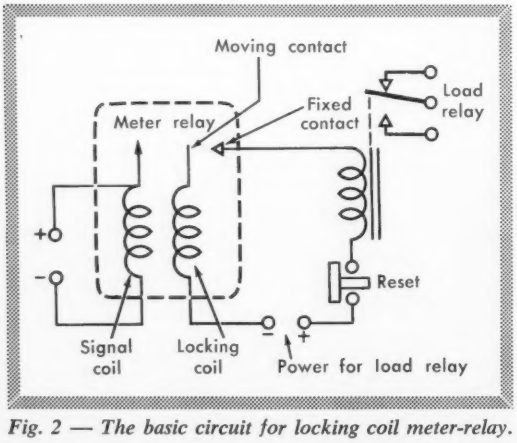


Fig. 2 — The basic circuit for locking coil meter-relay.

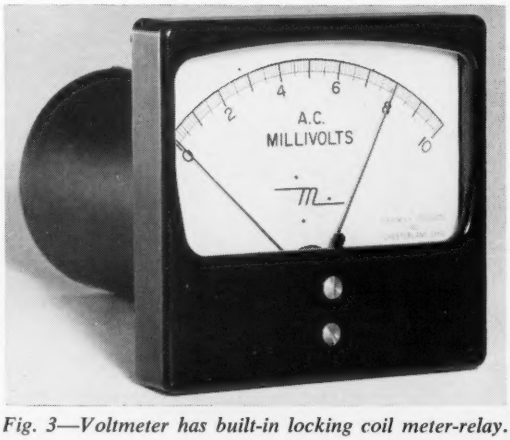


Fig. 3—Voltmeter has built-in locking coil meter-relay.

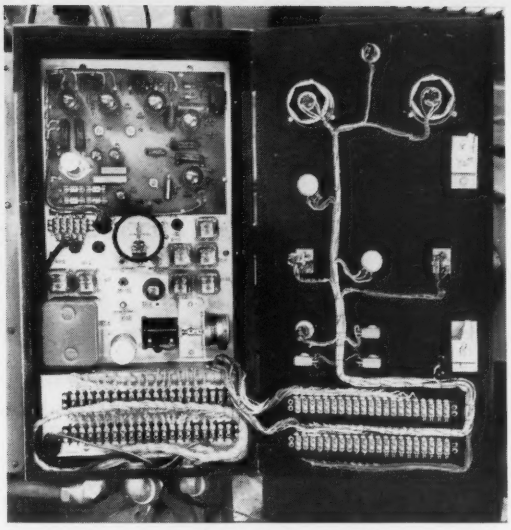


Fig. 4—Interior of electronic control (diagram below).

to 0 to 500 volts. Ranges below 75 millivolts come in dc only because of limitations of rectifiers; otherwise, all ranges are available in either ac or dc. Higher voltage or current ranges may be made with external multipliers, shunts or transformers.

Contact ratings are anywhere from 1 to 150 milliamperes and from 6 to 125 volts dc. Dc is best for the contacts, but half-wave or full-wave rectified ac is suitable. Unrectified ac causes arcing and welding. Meter relay contacts should never be over-rated. The locking coils of standard meter-relays operate on currents ranging between 5 and 25 milliamperes.

The power gain possible with meter-relays may be simply demonstrated. A 1 milliampere meter-relay at half scale (500 microamperes) requires only 50 millivolts, or 25 microwatts of power. Such a meter-relay is often used to switch a circuit of 300 milliamperes at 100 volts, or 30 watts. Power gain: 1×10^6. A lower torque meter-relay may require coil power at full scale of only 2.5 microwatts. It will switch 30 watts and thus realize a power gain of more than 10^7.

The fastest practical response time of a meter-relay is about the same as that of a panel meter, or about 100 milliseconds. (Response time is the interval required for the pointer to reach 99% of its deflection for a given applied torque). The designer must always keep in mind, of course, the response times of other units in a circuit with a meter-relay. A meter-relay's response time can be improved in various ways, especially by using more power.

Typical Control Application

Fig. 1 shows an electronic control that depends on meter-relays for its proper functioning. Developed for a machine that stretches and forms high-strength stainless steel with great precision, the control performs two general functions. It receives signals and translates them to determine automatically and accurately the yield point of the metal that is about to be shaped. Then it guides the machine during the actual forming so that the utmost is realized in physical qualities of the metal.

In the simplified circuit diagram (fig. 5) M-2 is the "strain" meter relay with a two-fold function, relatively routine but important: (1) it indicates in pounds, the tension being applied to metal in the machine, and (2) it immediately shuts down the machine if the metal breaks.

M-1 the main servo meter-relay and M-3 the "yield" meter-relay perhaps illustrate better, however, how meter-relays may be used with electronics circuits. M-1 is used with a differential amplifier, V-3 to compare two signals and then to simplify the control problems connected with this comparison. M-1 is a zero centre, double contact meter-relay. Its scale is blank and the range between centre-scale and either limit is only five microamperes, thus insuring precise control.

The purpose of M-1 in monitoring the output of V-3 is to maintain an electrical analog voltage equal to a reference voltage. Ultimately a servo motor is actuated to maintain proper pressure in an hydraulic system. No correction to the servo is needed as long as the variable signal from the amplifier (V-1, V-2) remains approximately the same as the fixed voltage from potentiometer P-9 (the "memory pot"). The variable signal is fed to the left grid of V-3 while the fixed voltage feeds the right grid. When the voltages remain the same the indicating pointer of M-1 stays at zero centre. Too much or too little voltage to the left grid unbalances the signal from V-3 to M-1. The indicating pointer of M-1 then swings up or down and makes contact with a fixed pointer. The "raise" and "lower"

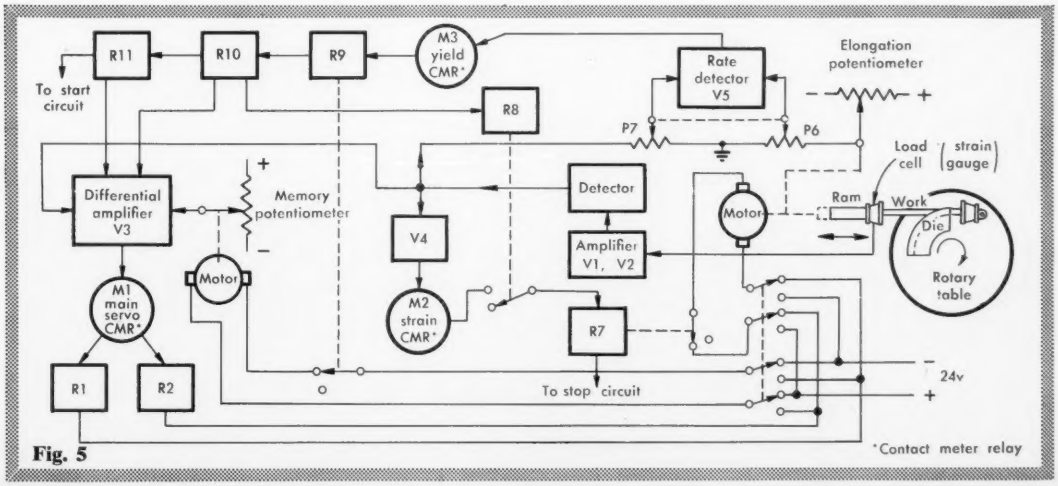


Fig. 5

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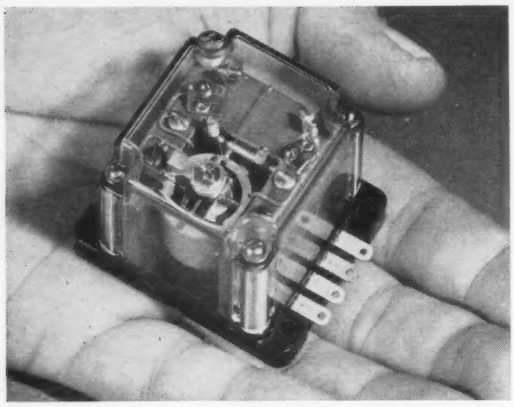


Fig. 6—Magnetic contact is another type of meter-relay.

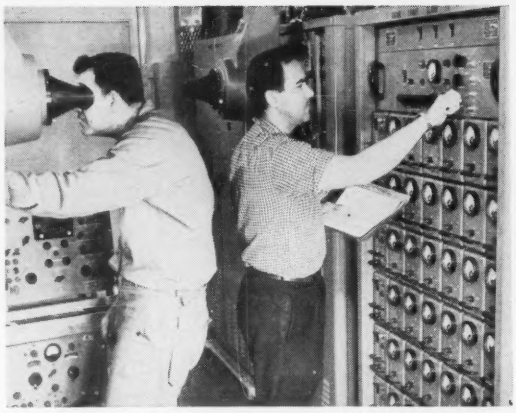


Fig. 7—Technician adjusts a panel of ruggedized relays.

relays R-1 and R-2 then actuate the servo motor as required.

As the circuit indicates, the same general procedure is also used to transmit corrective pulses to the motor driving P-9. Without the meter relays, a much more complicated amplifying arrangement would have been required.

Other Applications

A potentially broad field of application for meter-relays which is still comparatively new is vacuum tube voltmeter circuits. In almost all cases, a meter-relay can be inserted simply in such an electronic circuit in place of any indicating meter. The circuit then has built-in control or alarm features along with its unique ability, because of its high input impedance, to measure voltage without loading the circuit.

Many improved types of timing circuits can be devised electronically with meter-relays. The circuit in fig 5 required the high and low limit action of a meter-relay, but the problem was to avoid a starting surge that would drive the meter-relay to its high limit and shut off the motor being controlled before it had a chance to perform its desired function. Therefore, the time delay interval had to begin, not when the meter-relay contacts met, but when the signal was applied.

Initially the signal pointer of the meter-relay rests against the contact of the low pointer, which is set slightly above zero. The low contact is connected to the grid of the tube and a slight current is flowing enough to energize the tube. The locking circuit is open, so that neither the high nor the low contact is armed to lock.

When the signal surges from the motor being monitored, the indicating pointer is free to move. Even if it reaches the high set point, the load relay will not be energized because the high contact is temporarily disconnected. The movement of the indicating pointer from the low contact acts as a switch, removing the tube grid from ground. As a timing capacitor slowly discharges, the tube's conduction decreases. A relay is then de-energized and circuits are closed that disconnect the low contact from the grid and arm both the high and low contacts. The meter-relay is then ready to proceed with its control function, since locking will occur at both set points. ★

Glenn Krebs, author of this article, is Control Engineer, Assembly Products Incorporated of Chesterland, Ohio.

Fig. 8—Test control inspects selenium rectifier cells.

Fig. 9—Controller monitors irradiation of blood plasma.

Canadians at Design Engineering Show

DE staff report

Approximately 60% of the total registration of 18,000 viewed the Canadian exhibit, over 400 trade inquiries were made, and Canadian firms which took part expect to be busy for many weeks answering enquiries. Such were the direct results of the first Canadian participation in the Design Engineering Show, held recently in Convention Hall, Philadelphia. The long range results look even more promising.

The annual Design Show, as previewed in our May issue, was a four-day affair. Four hundred companies exhibited their products, and around 4,000 engineering experts answered the questions of the inquisitive.

Concurrent with the show an intensive conference was staged by the machine design division of the ASME. The sessions were divided into two days of general meetings and two days devoted to the specialized needs of engineers interested in the use of materials, mechanics or power and control.

The Canadian display

Twenty-nine Canadian businesses responded to the efforts of the Department of Trade and Commerce, Ottawa, and featured their products in the special Canadian section. Unfortunately, only 13 of the same companies saw fit to post personnel at the show to handle inquiries from interested viewers. This represents about half a man per exhibit, compared to the over-all show average of 10 men per booth.

Feature of the whole show was the cutaway model of the Orenda 11 engine. One observer was heard to say "I thought all they made in Canada were Eskimo carvings." As a result of the Orenda display, the company reports it had six good inquiries from U. S. organizations interested in sources of supply and work in Canada.

Some other Canadian companies represented were suppliers of die cast components, polyester moldings, hydraulic pumps, autoclaves, electro-hydraulic devices, magnetic sound equipment and automatic positioning machines. The AECL, Canadian Patents and Development, Ontario Research Foundation, and Tool and Die Manufacturers Association were also there.

Most Canadian exhibitors ran out of handbooks and other literature before the show was half over. The Canadian exhibit was chosen to be the section of the show featured in a news broadcast by the local tv.

Some observations

The Canadian display was good—what there was of it. The space should have been at least double what it was, and the number of companies represented should have been closer to one hundred.

This year no fee was charged to the individual companies, as the Canadian government footed the bill. We would suggest, that for future shows of this type, a "participation fee" be assessed, if only to impress upon the firms represented that the project is an honest-to-goodness promotional program. Every company should also have a representative present at all times.

In our opinion, the handouts from the Canadian exhibit were a little weak. Many firms had no literature at all available. Compared to some U. S. efforts, which included such items as plastic briefcases stuffed full of reading material and samples, the Canadians looked like the poor country cousins.

Finally, we must comment on the lack of imagination shown in preparing the over-all layout. Most booths at the show were lavishly decorated, expertly lighted and served as attractive backdrops for the products displayed. In some cases, the Canadian counterpart was merely set up on the floor, or placed on a table with little or no explanatory posters or information. And in spite of all this, the Canadian exhibit did attract wide attention and favorable reaction.

This is a show for engineers and business executives. As we said before, over 18,000 of them pay $2 admission fee to view the exhibits, and that means they have a genuine interest in seeing the best and latest in engineering design.

We trust that in future years, Canada will again be represented. The effect could be tremendous. ★

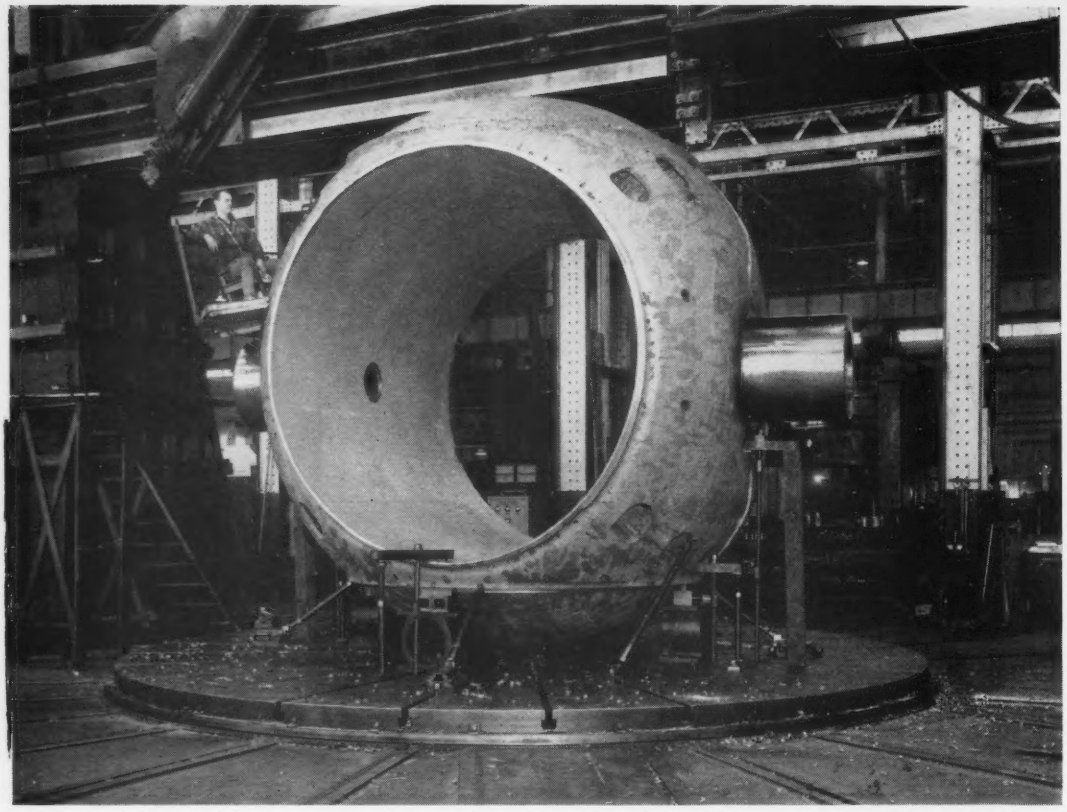


Fig. 1.—A monster of a valve. The plug is being processed here—notice welded areas on frontal lip nearest camera.

Spherical valve for high head service

A newcomer to hydraulic turbine valves with many outstanding features

During a recent visit to Dominion Engineering Company in Montreal, we obtained this information on the spherical valves they design and manufacture.

The spherical valve is a relative newcomer in the field of hydraulic turbine shut-off valves.

In its simplest form, it consists of a spherical plug, traversed by a cylinder of full valve size and supported on two trunnions in a spherically-shaped body, (see Fig. 2). A 90 deg movement of the plug on its trunnions presents to the flow of water in the penstock either the full-size bore or the blank spherical surface on the plug. A movable seat in the body (usually hydraulically actuated) engages a seat on the plug and makes the valve leakproof.

Outstanding advantages of the valve are: its compact mounting dimensions, exceptionally low head loss, low mechanical friction on lubricated surfaces and associated freedom from wear. The ease of arrangement for double seats (which makes it virtually a valve and guard valve combined), the accessibility on the seats for replacement, and above all its very definite superiority in freedom from leakage, make this valve an increasing favorite for medium and high head application.

In emergency service leakage causes little concern where the valve's function is complete if the flow is reduced to proportions that will bring the plant under control or which will cause no significant damage until more deliberately functioning equipment can be closed down.

This criterion of leakage is, of course, not acceptable for inspection or maintenance of the turbine. Leakage in this case is objectionable if it prevents access to the case or interferes with the efficient performance of the maintenance or inspection in hand. The maximum leakage for this service may be specified as that which can be taken care of by the casing drain with an adequate margin. There is no relation between leakage and strength, and leakage within reasonable limits should find acceptance.

When it comes to protection of the turbine gates, leakage becomes even more critical. Here leakage must be reduced to a minimum and absolute tightness is desirable.

The passages through a spherical valve produce little more head loss than the losses in the corresponding length of penstock. Advantage can sometimes be taken

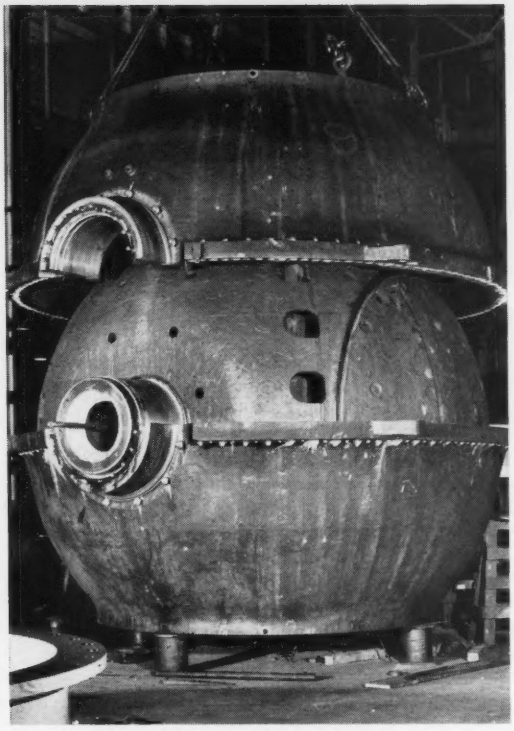


Fig. 2—The vital parts: plug, cylinder and trunions.

of this to effect economies by reducing the size of valve and using efficient diffuser pipes downstream. In this case, the head loss may be taken as the losses in the diffuser.

The cost of the valve can be expected to vary as some function of the diameter, commonly as the square, and a comparison of the value of the head loss in the diffuser with the saving in valve cost will indicate if economies can be effected by a reduction in valve size.

High head applications

The valve finds application in high head service, for which its proportions admirably suit it. The valve body is truly spherical, a shape which results in the lowest stresses due to internal pressure. But it is in the plug that the spherical valve design shows to best advantage. This must be a structure that can transmit to the trunnions the load from the highest penstock pressures, without undue stress or objectionable distortion.

The bending moment diagram for the plug shows that the maximum stresses occur at (a) at the trunnions or at (b) and (c). (See Fig. 3). The simple geometric shapes of the plug permit the maximum section modulus attainable within the confines of a spherical body. Loads applied within either the upstream or downstream seats give (at least approximately) the same distribution of bending moments, a condition which the symmetrical upper and lower sections of the plug admirably meet. This symmetry also results in the minimum distortion of the seating areas, a factor that contributes in no small measure to the freedom of the valve from leakage. ★

Bending moments

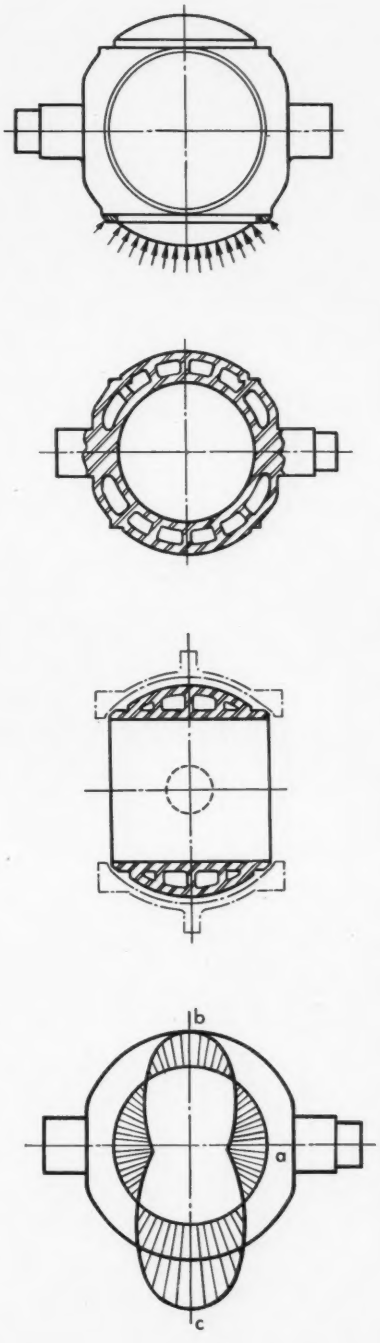
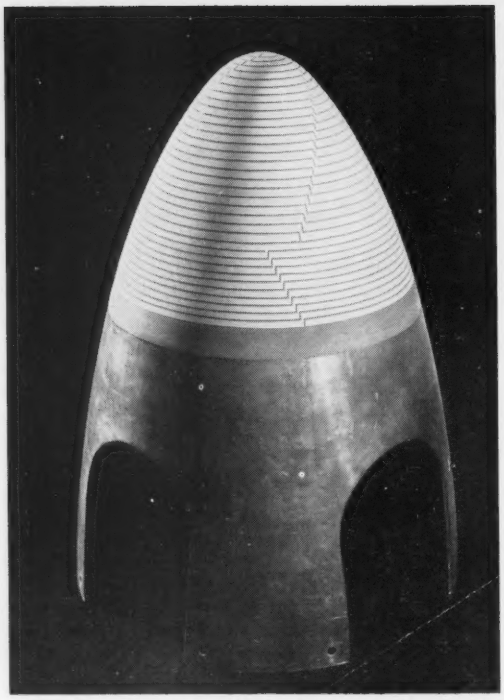


Fig. 3

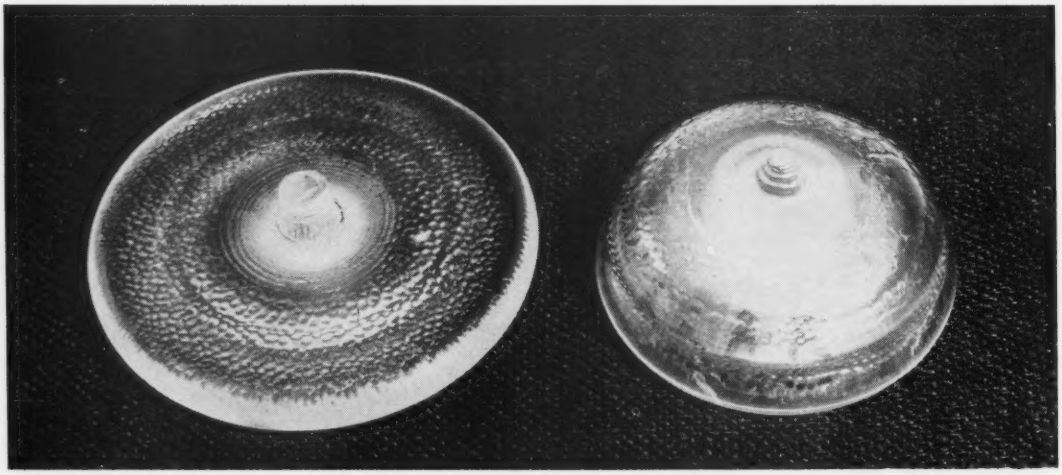
200—Universal impedance bridge has five separate circuits, is completely self-contained and portable, features a new mechanical and electrical design

201—Workmen are sorting out a maze of pipework on heat exchanger. Unit is a "cold" exchanger nitro evaporation cooler for a liquid oxygen plant in UK.

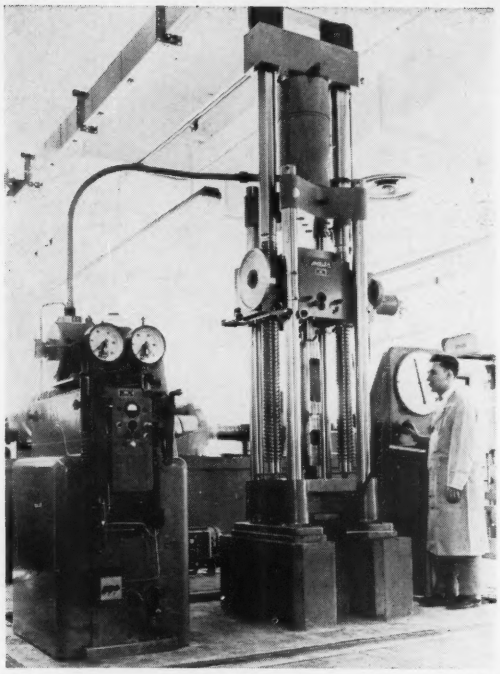


202—Propeller spinner fitted with a new heating device to eliminate ice build-up during flight. Sprayed on, thickness of the "mat" is not more than 0.050-in.

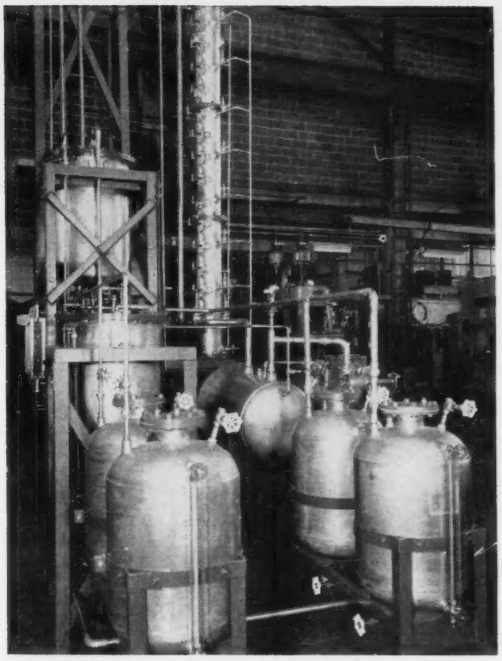
Design News in Pictures



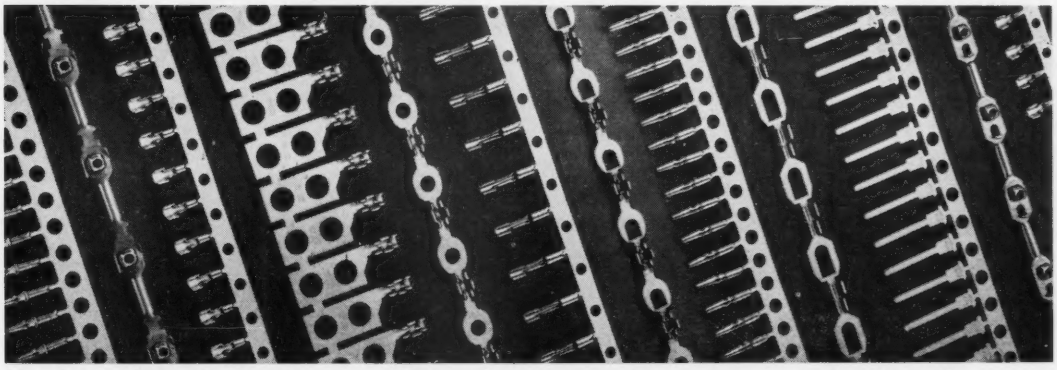
203—Synthetic sapphire windows for infrared, ultraviolet microwave applications can now be had in diameters up to 5 in., and in large contoured shapes. These two boules have been grown and annealed, but not polished.



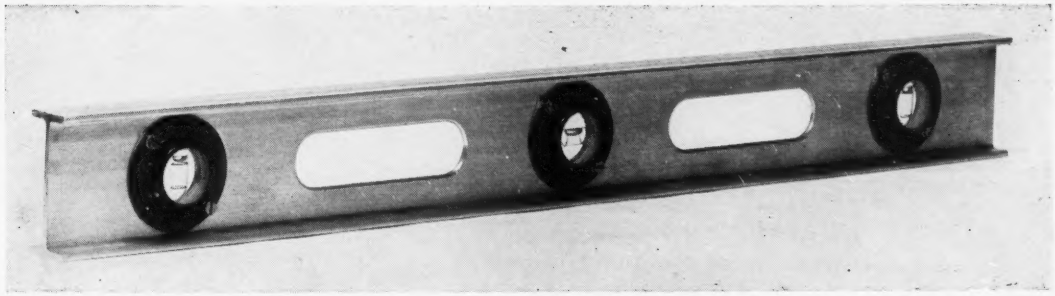
204—More muscle for bigger bolts. Giant 250,000 lb testing machine certifies fatigue test data on standard sizes of aircraft and industrial high strength bolts.



205—Packaged experimental laboratory distillation unit shown above was recently shipped to College of Engineering, Seoul National University, Seoul, Korea.



206—In the belief that there's nothing like an effective automation program for saving time and money, a company is producing miniature tubes, terminals, receptacles and connections in chain form for insertion machines.



207—Spirit level can measure three separate angles and dead level without readjustment. Of all-metal construction each tube is a hollow ground, barrel shaped hole drilled in solid plastic which reduces breakage hazard.

Simple mechanical vibrating systems

In practice, a vibrating system always presents some degree of damping. For quick calculations says author, an undamped system is very useful.

Eryk Kosko P.Eng.

The simplest vibrating system essentially consists of a mass which is attached to a solid foundation by means of a flexible spring. When at rest, the spring assumes a length such that its elastic reaction balances the weight of the suspended mass (Fig. 1). If now the mass is displaced from that position and released, or if an impulse is imparted to it, an oscillation about the position of rest will begin. If no external influences are present, these vibrations could continue indefinitely; actually, however, due to air resistance, friction and similar factors, the oscillations gradually decrease and finally die out. These external influences are generally termed as *damping*. Some further damping may be included on purpose, using such means as a dashpot, or making the spring of such material as rubber. Thus in practice a vibrating system always presents some degree of damping, and is schematically represented by Fig. 2. For quick calculations, however, the idealization of an undamped system is often very useful.

For the quantitative assessment of a vibrating system the following characteristics are of importance:

—the *mass m*

—the *spring stiffness k*, defined as the force necessary to extend or contract the spring by 1 inch;

—the *damping coefficient c* which is the force necessary to move the dashpot at a velocity of 1 in./sec.

An auxiliary quantity derived from the first two is the *static deflection* $x_{st} = W/k$.

Mr. Kosko is an associate research officer of the Structures Laboratory of National Research Council, Ottawa.

Free undamped vibrations

The mass describes a motion termed simple harmonic which can be characterized by the following:

—the *amplitude a*, or farthest displacement either way from the position of rest;

—the *period T*, the time necessary to describe a complete cycle.

Instead of the period, which in mechanical vibrations is often a fraction of a second, it is more practical to speak of *frequency f*, i.e. of the number of complete cycles per second; this is simply the inverse of the period: $f = \frac{1}{T}$. In order to simplify some of the calculations, use is made of the *circular frequency* ω, which is the frequency multiplied by 2π.

$$\omega = 2\pi f = \frac{2\pi}{T}.$$

A simple mathematical analysis shows that for an undamped system the period—and therefore the frequency—is independent of the amplitude of the motion, and remains constant; its value is given by the formula

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \ldots\ldots\ldots\ldots (1a)$$

a simpler form of which is

$$\omega_n = \sqrt{k/m} \quad \ldots\ldots\ldots\ldots (1b)$$

Free vibrations with damping

The main sources of mechanical damping are either dry or fluid friction. In the first case the

force which opposes motion is independent of speed (Coulomb's Law). On the other hand, fluid damping depends on velocity, the force being proportional to some power of the velocity. In general, it is sufficient to assume so-called *viscous damping*, with force proportional to velocity. Although the actual law may be somewhat different, this assumption is accurate enough; moreover it is more amenable to mathematical treatment than other postulates.

A damped free vibration is a decaying one, energy being dissipated in each cycle. For viscous damping, the ratio of the amplitudes of two successive cycles is constant. This means that the amplitudes diminish in a geometric progression without ever becoming completely extinct—at least in theory. A small amount of dry friction will however bring the system to a standstill.

The frequency of damped vibrations is also independent of the amplitude and remains constant throughout the motion; it is less than for undamped vibrations, as shown by the formula

$$\omega_d = \omega_n \sqrt{1 - c^2/(4km)} \quad \ldots\ldots\ldots (2)$$

A look at the expression under the square root shows that when the damping coefficient attains the critical value

$$c_{cr} = 2\sqrt{km} \quad \ldots\ldots\ldots\ldots (3)$$

the frequency becomes zero, i.e. we have an aperiodic motion or subsidence in which the mass slowly returns to its position of rest. The same happens when the damping exceeds the critical value.

In the free undamped vibration of a mass, the frequency is independent of the amplitude of the motion and remains constant.

With damped free vibration energy is dissipated with every cycle and the amplitude theoretically diminishes in a geometric progression.

Various formulas and an alignment chart are presented by the author to provide ready solution of the problems involved.

Glossary of Symbols

Symbol	*Unit*	*Definition*
a	inch	amplitude of steady forced vibration (i.e. maximum deflection from position of rest)
c	lb.sec/in.	damping coefficient of dashpot
f	cycles/sec	frequency of vibration
g	ft/sec^2	acceleration due to gravity
k	lb/in	spring constant
m	lb.sec^2/in.	vibrating mass $= W/g$
n		magnification factor
P	lb	amplitude of exciting force
q		damping ratio
Q		selectivity
r		frequency ratio
T	sec	period of oscillation
W	lb	weight
α	inch	displacement from position of rest
ω	radians/sec	circular frequency
subscripts		
0		at zero frequency (i.e. quasi statical)
cr		critical
d		damped
n		natural (undamped)
r		at resonance
st		static

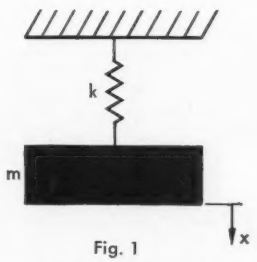


Fig. 1

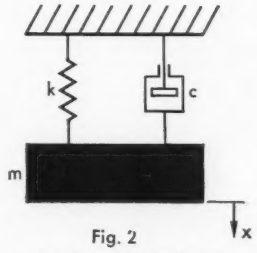


Fig. 2

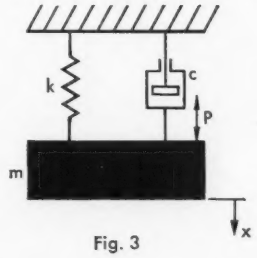


Fig. 3

continued

Forced vibrations

When an oscillating force acts on the mass—such as may happen in the case of an unbalanced motor attached to it—the resulting vibration has the same frequency ω as the exciting force. The amplitude of the forced vibration is obtained from a formula,

$$a = P[(k - m\omega^2)^2 + c^2\omega^2]^{-\frac{1}{2}} \quad \ldots\ldots \quad (4)$$

which is somewhat unwieldy. As an alternative, an alignment chart is presented herewith; it gives the relation between three non-dimensional quantities: the frequency ratio, the damping ratio, and the magnification factor. As a preliminary step, the following quantities must first be evaluated:

—Natural undamped frequency f_n, or circular frequency $\omega_n = \sqrt{k/m}$

—Critical damping coefficient $c_{cr} = 2\sqrt{km}$

—Quasi-static displacement (the displacement when the load P is applied very slowly) $a_0 = P/k$.

The non-dimensional quantities to be aligned in the chart are:

—Frequency ratio $r = f/f_n = \omega/\omega_n$

—Damping ratio $q = c/c_{cr}$

—Magnification factor $n = a/\alpha_0$.

From the formula (4) it appears that when no damping is present and the frequency of the exciting force coincides with the natural frequency of the system (resonance case), the denominator is equal to zero, and the amplitude may become infinitely large. Such will not be the case when damping forces are at work. In fact, the amplitude at resonance (i.e. when $\omega = \omega_n$) is given by

$$a_r = P/(c\omega_n) = \alpha_0/(2q)$$

The factor $Q = 1/(2q)$ is sometimes called the *selectivity*, in analogy to electrical oscillating circuits.

The magnification factor is important from the stressing point of view, as the maximum stresses in the spring are proportional to the displacement amplitude. Under the alternating force the stresses are magnified in the same ratio as the displacement.

The forced vibration follows the excitation at the same frequency, but with a certain time lag, which is a function of both the frequency ratio and the damping ratio. The peak displacement occurs a fraction of a period later than the peak of the exciting force. The amount of that lag is usually expressed as a phase difference, but we shall not include any formulas for it in this short survey.

Torsional vibrations

All the above considerations and formulas remain applicable when dealing with systems which can rotate about an axis, provided the following substitutions are made:

—for linear displacement amplitude a substitute an angular amplitude measured in radians;

—for mass m substitute a moment of mass inertia about the axis of rotation;

—for linear spring stiffness k substitute a torsional stiffness (i.e. the ratio of torque to angular displacement, in.lb/rad);

—for damping force coefficient c substitute a damping torque coefficient (i.e. a torque per unit angular velocity, in.lb.sec/rad);

—for amplitude of the exciting alternating force P substitute the amplitude of an exciting alternating torque.

Numerical example

An electric motor-pump aggregate weighing 120 lbs. rotates at 1800 rpm; the rigidity of the mounting is 7660 lb/in.

(1) What is the natural frequency of the free oscillations?

The mass is

$$m = \frac{120}{12 \times 32.2} = 0.3105 \text{ lb.sec}^2/\text{in.}$$

The circular frequency is, according to formula (1b),

$$\omega_n = \sqrt{7660/0.3105} = 157.1 \text{ rad/sec.}$$

or

$$f_n = \frac{1}{2\pi} \times 157.1 = 25 \text{ c.p.s.}$$

$$= 1500 \text{ cycles/min.}$$

(2) In steady rotation, some unbalance causes vibrations of an amplitude of 0.050 in. What is the amplitude of the exciting force, assuming damping to be negligible?

For a frequency ratio $r = \omega/\omega_n = 1800/1500 = 1.20$ and zero damping, the alignment chart gives at point (1) a magnification factor of $n = 2.273$. The quasi-static deflection amplitude therefore is

$$\alpha_0 = \frac{a}{n} = \frac{0.050}{2.273} = 0.022 \text{ in.}$$

The exciting force has an amplitude of

$$P = k\alpha_0 = 7660 \times 0.022 = 168.5 \text{ lb.}$$

(3) How much would the amplitude of the vibrations be reduced by introducing viscous damping of the order of 0.5 of the critical value? What would be the required value of the damping coefficient?

Aligning on the chart the values $r = 120$ and $q = 0.5$, we find at point (2) a magnification factor (in this case it is a reduction factor) $n = 0.785$. The resulting vibration amplitude is $a = 0.785 \times 0.022 = 0.017$ in., i.e. 34 per cent of the undamped amplitude.

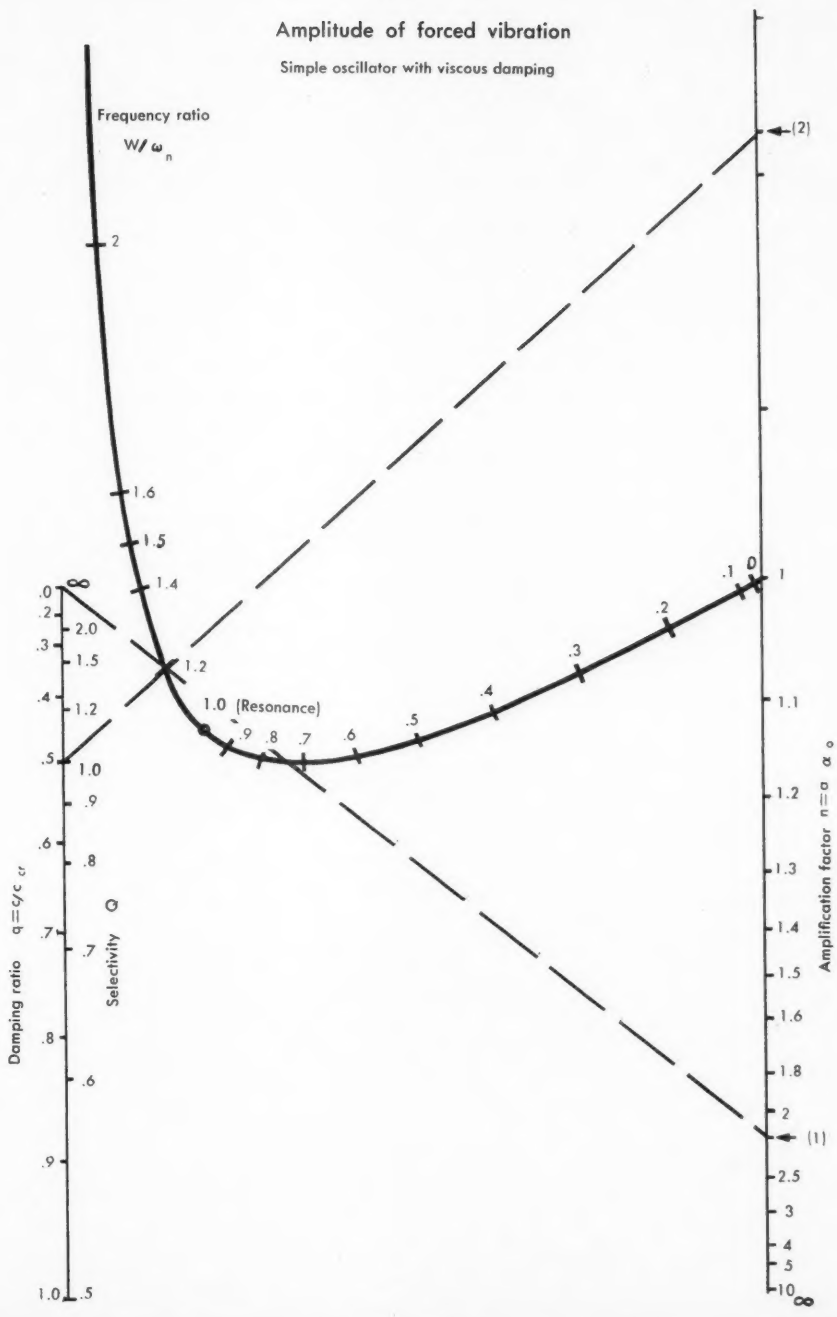
The critical damping coefficient is, by Eq. (3),

$$c_{cr} = 2\sqrt{7660 \times 0.3105} = 97.3 \text{ lb.sec/in.}$$

The required value is thus $0.5 \times 97.3 = 48.65$ lb.sec/in.

DATA SHEET

Damped Vibrations–



Exclusive DE Feature

Designers: keep your eye on the (steel) ball

T. H. Beard P.Eng.

The common or garden-type steel ball is a versatile item. Its uses are limited only by the extent of the designer's ingenuity. Its main use, of course, is in the field of anti-friction bearings, but its many properties make it ideally suited for service in other facets of machine or tool design.

Some commercial uses are well known — the penetrator in the Rockwell Hardness Tester and the "pawl" in the ratchet-free clutch. In the hope of stimulating further uses for the little fellow, here are some applications where the steel ball has proved helpful.

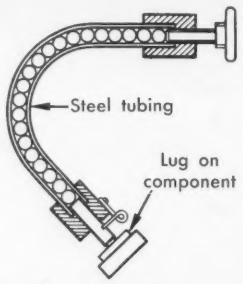
1. Clamping-pressure applied around corners.
A quantity of balls, trapped in line in steel tubing will transmit force like a fluid in a hydraulic cylinder. The tubing can be bent so as to by-pass obstructions, and with this system there is no problem of oil leaks. For moderate clamping pressure, the tubing should be brazed in the end blocks. For only light pressure, however, standard tube fittings can be used.

2. Equalizing Clamp.
The balls are sandwiched between two plates, in a machined groove as shown. When the clamping plate is brought down, the component squares up on the machined surface with full support being supplied to the lower rough cast face by the ball system.

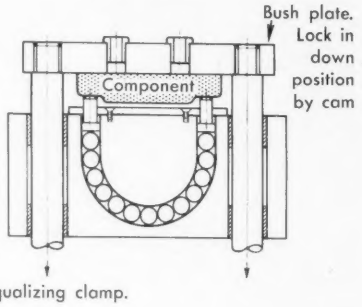
3. Expansion Clamp.
A low cost but powerful expansion clamp can be made by using three equal sized balls to act as the expanding collet segments with a centre ball to do the expanding. Only one application is shown here but the principle can be applied to an unlimited number of cases.

4. Swivel End Clamp.
An easily made self adjusting clamping pad can be made by using a suitably sized steel ball. The ball should be given a good initial seating in both parts by hammering in place with a lead block.

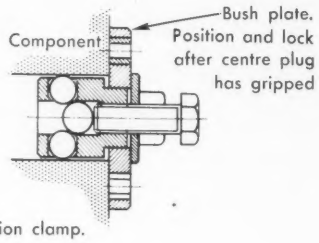
5. Securing Studs.
The normal way of securing studs by tightening down to the plain part gives no guarantee that the stud will stay put. But if the end of the stud is given two cross cuts with a hacksaw and a small ball is dropped into the hole, the stud will hold. Tightening down the stud causes the bottom end to spread and grip the threads.



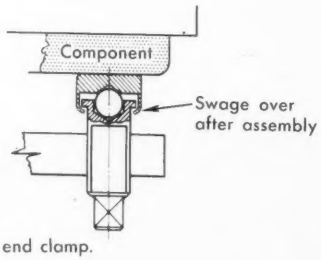
1. Clamping pressure applied around corners.



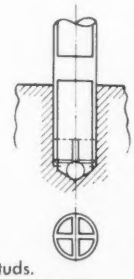
2. Equalizing clamp.



3. Expansion clamp.



4. Swivel end clamp.


5. Securing studs.

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(2) Text—complete and without supplementary notes or comments.
(3) Appendices.
(4) References.
(5) Tables.
(6) Illustrations, with captions on a separate sheet or sheets.
(7) Photograph and short biography of author.

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Mathematical work should be hand-lettered, unless a special typewriter is used. Particular care must be taken to identify special symbols, Greek letters, etc., and to distinguish between such characters as lower case o, capital O, and the zero sign 0, and the letter l, capital letter I and figure 1. The correct position of subscripts and superscripts must also be clearly indicated.

References should be noted by the use of superscripts in the body of the text and the list of actual references collected at the end of the article.

Abbreviations shall conform to CSA Z85—1943.

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Generally speaking, not under two and not more than three illustrations per printed page are considered to be the ideal arrangement.

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Glossy prints, preferably 8 in. by 10 in., but not less than 5 in. on the long dimension, are required. Negatives may be used, but the prints are preferred. It is recommended that photographs be taken by professionals.

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All illustrations, whether photographs or diagrams, should be clearly identified (fig 1, fig 2, etc.) and the relevant caption pasted to the back of the illustration or listed on a separate sheet. **Writing with a pen or pencil should never be done on the back of an illustration.**

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Author's photograph and biography

This information is used to identify the author on our "Author's Page." It is suggested that the photograph of the author be taken by a professional photographer. The pose should be quite informal, and preferably not show the author behind a desk. (There is nothing original in such a pose.) "Off-beat" photos, incorporating a hobby or family reference, are welcomed.

The biography should give all pertinent details, including important dates, education, professional qualifications, professional associations, work history, marital status, hobbies, and any other items that might be of interest. This information may all be listed in simple fact form, and our editors will prepare the actual material for publication.

Briefs

We note with interest . . .

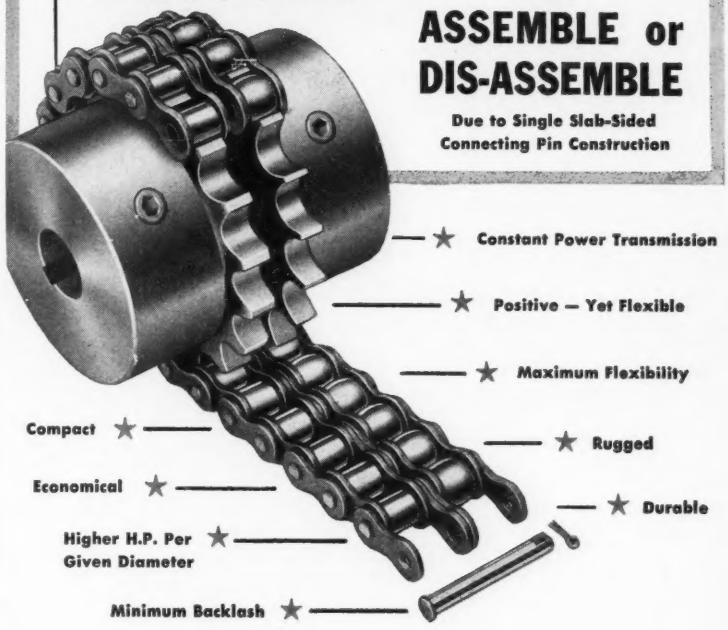
that competitive nuclear power using organic cooled and moderated reactors of 300,000 kw is predicted in the next few years . . . **the latest information** and methods on creating weather conditions by artificial means is on the agenda for a Weather Modification Conference, Aug. 27-29 in Denver, Col. . . . **The American Home** Lighting Institute says that the average 1,200-sq.-ft. house today has 12.2 lighting fixtures whereas it should have a minimum of 26. If you keep falling flat on your face — check your lighting fixtures . . . **we are told** that the American Society for Testing Materials have published their 1,430-page volume of 1958 ASTM proceedings . . . **Lethbridge** is the site for the first integrated edible oil processing plant in Western Canada . . . **"Asahi Shimbum"** a Japanese newspaper with one of the largest circulation figures in the world, now prints an edition 500 miles away by use of microwave facsimile negatives of the pages . . . **more monthly sandwich news** — this time with a mild steel filling and Type 301 stainless steel used for the "bread." Application is an auto bumper that will never pit and peel . . . **Sperry** Gyroscope of Canada tell us that their counterpart in the U.S. has been appointed navigations systems manager for the 608-class Polaris submarine . . . **a new internal** combustion engine developed in France is said to operate on any kind of oil or fat (Chez Papa now brings home the bacon for the family auto) . . . **talking of shooting,** a manufacturer of rifles and revolvers is now making the barrels from MT 1015 carbon steel tubing instead of bronze, at saving in material and machining costs . . . **"Money Minters"** a 16mm color film tells the story of the Royal Canadian Mint: has won an award of merit in the 11th Annual Canadian Film Awards. It may be borrowed through Inco . . . **service tests** are now being conducted with large nylon machine parts (gears and rollers) up to a size of two ft. — all by new casting method suitable for mass production . . . **we've just taken** a peak into the future and find that interior walls, rug and wall fabrics as heating sources, lighting systems, furniture, and building panels will all likely be made with aluminum . . . **congratulations** to one of the oldest automotive companies in the Dominion — the FWD Corp. now celebrating its 40:h anniversary . . . **we've decided** to start

(Continued on page 52)

Here's the Easiest FLEXIBLE COUPLING to ASSEMBLE or DIS-ASSEMBLE

Due to Single Slab-Sided Connecting Pin Construction

★ All Teeth Hardened — Hubs and Bores Remain Soft to Permit Reworking. Also Available in Finished Bores including Keyway and Setscrew.



Acme Flexible Couplings are quickly assembled or dis-assembled by means of a chain that has only one pin to connect or remove. Connecting links are permanently positioned on chain to engage connecting pin without difficulty in assembly. Positive Power Transmission is assured, with provisions for both angular and parallel misalignment. They absorb shock loads, provide maximum flexibility with minimum backlash. All steel construction to give maximum life expectancy. You save money in the *long run.*

Acme Flexible Couplings and Roller Chains are available nationally through your local Industrial Distributor. Be sure to specify ACME.

Write Dept. 20 F for Special Catalog CPI-57 on Flexible Couplings.

Call ACME for Service

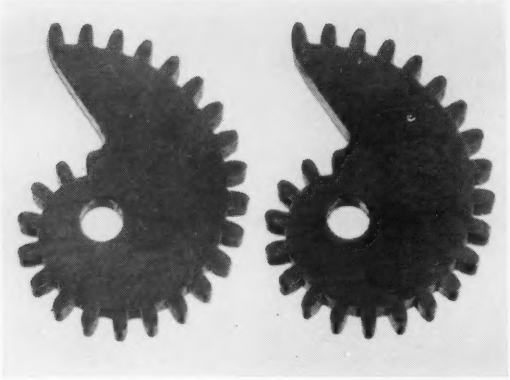
Acme Chain Corporation
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

Circle number 101 on time saver card

Ideas round-up

Intricate gearing in zinc die-casts



Zinc die-casting has helped solve an intricate gearing problem at low production cost for Minnesota Mining & Manufacturing Co. in its Thermofax copying machines.

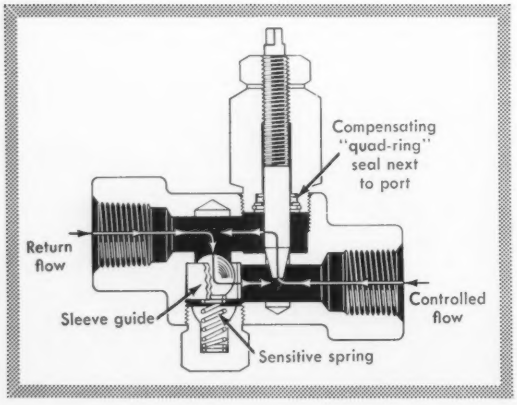
The operating mechanism of the copying machines requires a pair of identical, mating variable-pitch gears, each working from a fixed centre. (Non-circular gears of this type were discussed in DE, October 1957.) The gears have 23 teeth, each of which is differently shaped. Pitch radii range from .240 in. to .840 in., the teeth are undercut, and none converges to a common centre. Because there can be no adjustment of shaft centres, tolerance requirements for the teeth are quite close (± .001 in.).

Investment casting had formerly been used for the job, but because of its cost, the gears are now made as zinc die-castings. Exact uniformity of tooth shape, radii and angles from piece to piece, are thus obtained at a small fraction of the investment casting cost. No machining whatever is required. The parts are so precisely duplicated that any two gears can be relied on to mesh perfectly, without danger of mis-alignment.

The zinc gears allow the highest degree of functionability with no variation of tooth engagement at centre positions; their accuracy makes the operating mechanism of the Thermofax especially smooth.

In production, the stationary core forming the shaft hole is on the same half of the die as that forming the teeth. The die-caster needs only cast and trim. **(208)**

Flow control valves for hydraulic or air cylinders



Flow-control valves, with forged aluminum bodies (Auto-Ponents, Inc.), feature oversize internal passages and large ports, to provide greater accuracy and response in the control of hydraulic or air cylinders. While they are designed to produce optimum control and sensitivity in both oil and air applications, the oversize ports and passages (for minimum pressure drop and loss of power) make the valves ideal for hydraulic circuits where maximum flow is required for maximum efficiency. Valves with forged aluminum bodies are designed for pressures up to 3,000 psi. Forged steel and stainless steel valves for higher pressures will be announced later.

The compactly designed body combines a supersensitive check valve which permits full flow in one direction, with a long tapered pointed vernier thread needle which provides a wide range of flow adjustments in the opposite or controlled direction.

Flow adjustments under full rated operating pressures are possible, due to the use of a compensating type pressure gland (using a Quad-Ring seal) which allows self-alignment without leakage or abnormal wear. The gland is purposely located next to the pressure port, to seal off the threads in the needle housing, so that the needle can turn easily under the highest pressure. A long, pointed needle with fine vernier threads, insures precise flow adjustments. **(209)**

Fire and explosion hazard reduced with electrostatic locator

The presence of electrostatic charges and induction in industrial processes can constitute a serious fire and explosion hazard and frequently introduces production difficulties by causing erratic behavior of certain materials during processing. Remedial steps can be taken readily when the location and relative intensity of charges are known. Such information can be obtained easily with the Simco Electrostatic Locator. Leading processors of textiles, rubber, chemicals, paper, plastics and other materials both in this country and abroad are finding it a valuable aid to their operations.

Absolute measurement of electrostatic charges involves complicated calculations in which relative humidity, distance of the meter from the charged object or material, and the size, shape, composition and orientation of the object must all be taken into account. Such calculations require skilled technical personnel and may at best be of very low precision. In contrast, no previous experience is needed for the interpretation of readings obtained with the electrostatic locator. By merely pointing the probe of the meter toward the charged object, the meter is read.

The linear scale of the meter is graduated—10, 5, 0, 5, 10+, indicating the polarity and relative magnitude of the charge. Thus by taking comparative readings under a given set of conditions, the proper location for corrective equipment can be established and its effectiveness periodically checked. Three sensitivity ranges of the meter are available by adjustment of apertures built into the probe.

The electrostatic locator weighs less than three pounds and contains its own source of power. The power is supplied by one standard flashlight cell requiring replacement every six months and by two standard 4½-volt dry cell batteries which, in normal usage, require replacement once a year. All batteries are accessible by removing the rear cover plate which is secured by snap fasteners. Those parts of the instrument most likely to be affected by moisture or dust are hermetically sealed to assure long trouble-free life.

Operation and maintenance instructions are permanently lettered on the rear cover plate, eliminating the necessity of reference to a separate instruction book, and diagrammatic battery replacement instructions are attached inside the rear cover plate. **(210)**

Transistor performance checked with in-circuit tester

A transistor tester, that can check the performance of transistors while they are connected in their circuits, is being produced by Philco Corporation.

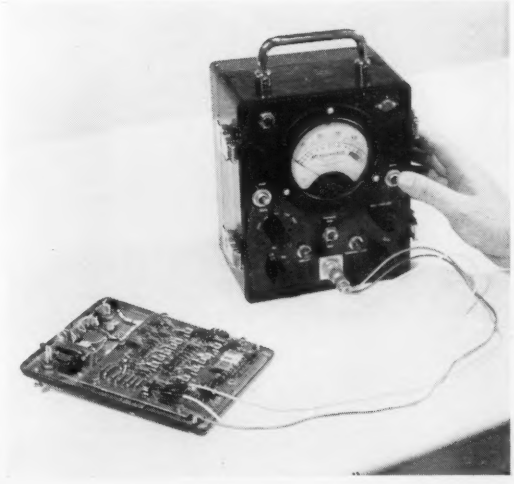
Under a previous contract, Philco design engineers developed a particular combination of transistor circuits that resulted in this technical break-through: an in-circuit transistor tester.

A commercial model of the tester will be available in the near future.

In-circuit transistor testing is extremely important, since the method saves trouble-shooting and servicing time, without turning on power in the equipment.

They are able to differentiate between normal input and output signals generated by the transistor and spurious signals appearing at either the input or the output terminals. These spurious signals arise from the sneak paths propagated by the circuitry surrounding the transistor under test.

Low impedance methods are employed in both the input and output circuits, to nullify the effects of the external circuitry. **(211)**



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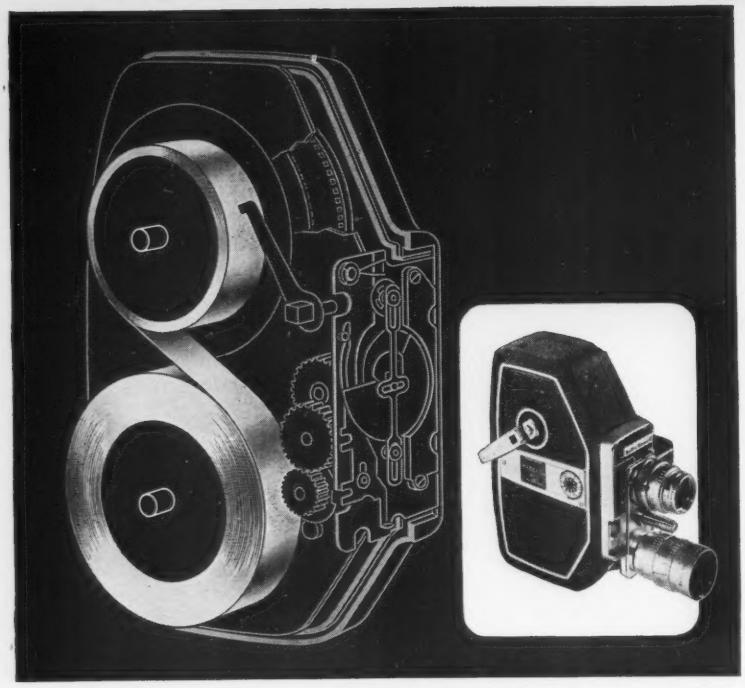


New Bell & Howell Movie Camera

DRIVEN BY A NEG'ATOR* MOTOR

Another top motion picture camera manufacturer has adopted the NEG'ATOR Motor as a camera drive unit.

As shown above, Bell & Howell engineers have designed a NEG'ATOR Spring Motor and have applied this motor to their new Series 240 Movie Camera. By doing so, they gained the following distinct advantages.

. . . longer film run per wind. The NEG'ATOR drives 32 feet of film per wind or 80 seconds of continuous shooting at normal speed of 16 frames per second.

. . . no "jump" or "skip." The NEG'ATOR solves an old mechanical motor problem by releasing spring energy smoothly without intercoil friction.

. . . excellent speed regulation. The NEG'ATOR provides a maximum output torque of 4.0 lb.-in. at full wind and maximum torque decrease is only 0.8 lb.-in. (20%) during entire output run.

. . . simplified mechanism. Bell & Howell engineers took advantage of the NEG'ATOR's level torque curve and designed an ingenious, low-torque, loose-ball governor which saves space and gives excellent speed regulation.

This application represents still another instance where a NEG'ATOR Spring provided the means for product improvement at reduced cost. Many other such examples are included in Hunter Bulletin 310N. Why not send for a copy now?

**NEG'ATORS is a registered trade mark of Hunter Spring Company.*

HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

25 Spring Avenue, Lansdale, Pennsylvania

SPRINGS · STAMPINGS · QUALITY CONTROL EQUIPMENT

Circle number 120 on time saver card

Briefs (Cont. from page 49)

collecting old watches after reading that a nickel-chromium-iron alloy in the form of hairsprings in watches, costs about $50,000 a lb. — or about 100 times the cost of gold . . . **just in case** artists are lurking in our midst, a new book has been published with the title "Sketching with the Felt-Tip Pen" . . . **trust the British** to be way ahead in the production of bottle caps. They have a machine now for manufacturing bottle caps at the rate of 10,000 an hour. Don't lick your lips in anticipation, however, caps are for medicine bottles . . . **we couldn't** *bear* to crop the lawn with one of those new mowers which "freezes" every blade of grass upright for clean cutting — it sounds too barbaric . . . **we read a report** by a member of the Board of Broadcast Governors recently, it said: "I believe that such recordings (hit-parade tunes) when heard hour after hour, make a mediocre contribution to the spirit . . . moreover, I consider them as drugs whose usage quickly produces a bad effect." We applaud, though think it's putting it too mildly . . . **a chap we heard of** bought a painting at an auction sale for $20. Suspicious, he took it to an expert who pronounced it a 16th century van Scorel. Our hero took it to New York — collected $8,000 for his trouble. It's good to know these things still happen . . . **an international** working partnership in the industrial design field has been arranged between Sundberg-Ferar Inc. of Detroit and Form und Technik of Baden-Baden, West Germany. Idea is to foster interchange of ideas between designers on both sides of the Atlantic . . . **ASTM plan** 53 technical sessions at the 3rd Pacific Area National Meeting in San Francisco — October 11-16 . . . **mysterious,** million - miles - an - hour shock waves thrown out by storms on the sun have been duplicated in a laboratory, we hear. Items like this never fail to impress us. But never as much as the shock waves we experience when we find the buff envelope from the Income Tax people doesn't contain a refund cheque — but a demand for more money . . . **an item of company news** is that Dowty Equipment Co. has appointed Richardson Equipment Co. as its exclusive distributor in Ontario and Quebec . . . **Nothing Like** Originality Dept.: take a slab of plywood, paint it blue, sprinkle liberally with colored glass chips, pour on some pigmented polyester resin, then cover with a sheet of transparent plexiglas. What is it, you say? Why the menu for a new kind of cocktail table . . . **an item from Tulsa,** Okla., says germs that eat gas are being put to work to find oil. Theory

(Continued on page 60)

People in the news

Robert C. McDermott has been appointed manager, electric product sales, eastern district of the Linde Company.

★ ★ ★

A. V. Orr becomes manager, Canadian sales of Atlas Steels Ltd., Welland, Ont. Orr is a Queen's University graduate in metallurgical engineering.

Three executive changes have been announced by Dominion Bridge Co. Ltd. **R. A. Reid** becomes manager of manufacturing services at Lachine, P.Q. He is a McGill graduate in mechanical engineering. **D. C. Holgate** (Acadia and McGill) becomes general manager of the Winnipeg branch. **J. B. Phelan** assumes the post of general manager of the company's Sault Ste. Marie branch. A graduate of the University of Toronto, Phelan was recently erection manager of the Toronto branch.

★ ★ ★

Wallace R. Morris has been appointed vp of Crane Packing Co. In this capacity he will act as managing director and secretary of the Canadian company.

★ ★ ★

F. H. Pounsett has been elected vp engineering and manufacturing, radio and TV division, of Philips Electronics Industries Ltd.

Morris

Pounsett

Dr. Horace B. Speakman, a distinguished Canadian scientist, recently retired as director of the Ontario Research Foundation. A native of England, Dr. Speakman came to Canada 43 years ago. For 10 years he was Professor of Zymology at the University of Toronto. In 1928 he was brought in to direct the newly-created ORF. From a staff of six, this organization has grown into a scientific institution with a world-wide reputation.

★ ★ ★

Ernest Quastler becomes plant manager of the Ex-Cell-O Corporation of Canada's London, Ont. plant.

★ ★ ★

Douglas B. Annan has been appointed sales manager, guided missiles division of DeHavilland Aircraft of Canada Ltd. A native of Hamilton, Ont., Annan is a graduate of Queen's University (metallurgy class of 1940).

A. Monsaroff assumes the responsibilities of executive vp of Monsanto Canada Ltd. He is a Fellow of the Chemical Institute of Canada and holds a B.A.Sc. degree in Chemical Engineering from University of Toronto.

★ ★ ★

The Canadian Welding Bureau has appointed **Joseph T. Biskup** as chief welding engineer. His duties will be to assist fabricators of bridges, buildings and machinery to meet the conditions laid down in the various welding codes of the Canadian Standards Association. Biskup has a wide background of experience and has been largely responsible for the welding of a number of outstanding Canadian buildings in recent years. He is a member of the Professional Engineers Association of Ontario.

★ ★ ★

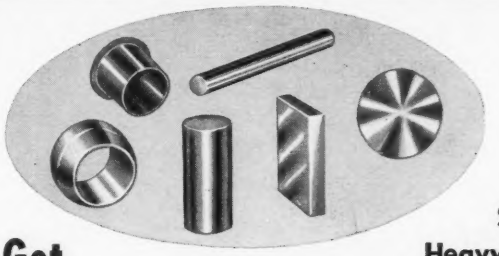
Robert H. Rastorp has been promoted manager, advertising and sales promotion department, Linde Company, Division of Union Carbide Canada Limited.

★ ★ ★

William M. Hummel, of Port Credit, has been appointed exclusive sales representative for the Province of Ontario and Quebec, for Leetronics, Inc.

★ ★ ★

Charles Rogers has been appointed advertising manager of General Products Mfg. Corporation Limited. ★



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for heavy loads at moderate speeds. Absorb shocks and stresses. IDEAL in areas difficult or impossible to lubricate. FROM STOCK. Also OILITE Bearing Material, cores, solid bars, plates, discs and strips.

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TORONTO MONTREAL THREE RIVERS QUEBEC CITY

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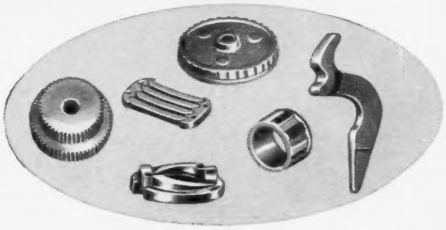
Precision Finished Machine Parts

are die-pressed metal powder parts. Quiet, long lasting. Self-lubricating if desired. Often produced for less than rough castings. Prompt deliveries.



Porous Metal Filters

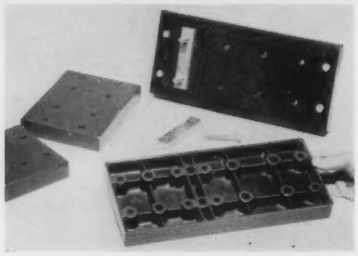
provide uniform depth filtration of particles as small as 2 microns. Strong. Unusual freedom of design. Wide choice of shapes, sizes, porosities and materials. Can be plated and are easily bonded to other metals.

Circle number 129 on time saver card

New products & materials

Bus distribution plates

Standard bus distribution mounting plates are now being made to recognized dimensional and performance standards. They are said to eliminate the need to custom-fabricate required plates from plastic sheet stock, and speed assembly of many types of electrical control devices. Blocks are molded of polyester plastic reinforced with glass fiber. High impact and dielectric strength, and good corrosion resistance are claimed. Plates



are 1¼ in. thick, 6½ in. wide (to carry 4½-in. bars) and are made in three lengths, to hold one, two, or four bus bars. **Synthetic Development Co.** make the plate. **(215)**

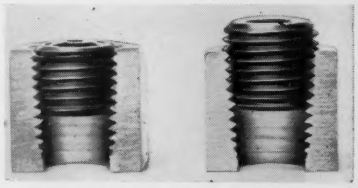
Aluminum ladders

Box section side rails extruded from special high-strength/low-weight aluminum alloy, and a newly designed rung-to-rail suspension are features of a new line of aluminum ladder. Rungs are hydraulically driven into side rails and internally expanded to form an integral, immovable joint. According to **Chelsey-Sarnes Ltd.** the inherent strength provided by box section side rails, combined with their new "Tork-Lok" rung construction, eliminates objectionable side .sway and racking common to open-section channel and "I" beam ladders. **(216)**

Flush-seating pressure plug

Flush-seating pressure plugs are now being offered commercially. When installed in hydraulic, pneumatic or other fluid pressure systems, the new hex socket plugs seat virtually level with the material into which they are threaded, say **Standard Pressed Steel Co.**

The new seal also has a different taper from that of the tapped hole — a feature which provides a positive leakproof seal without compound even under high fluid pressure.



Secret lies in the interference fit resulting from a deliberate interference in taper between the plug and tapped hole. Additional control is obtained by an improved method of production gauging. **(217)**

Motor gear reducer

Believed to be the only product of its kind, this unit consists of a gear-type fluid motor mounted as a part of a planetary gear reducer. It was designed for use in driving rotary soldering, welding or heat treating fixtures; powering hoists, cranes or rope drives; turning turrets and platforms; driving elevators, conveyors, even earth augers.

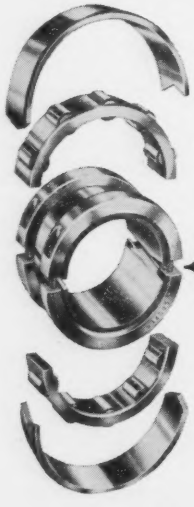
The high reduction ratio (4.6:1) assures smooth output even at lowest shaft speeds. The components were designed to provide 150-foot-pounds of output torque when used with an oil source capable of providing 1500 psi.

The unit mounts on an SAE standard 4-bolt D size hydraulic pump mount. Its over-all dimensions are about 8 in. x 8 in. and the unit projects about 7½ in. from the mounting surface. **Webster Electric.** **(218)** ★

SAVE "DOWN TIME" WITH

COOPER

split ROLLER BEARINGS



Split right down to the shaft

Cooper Split Roller Bearings have all the advantages of conventional roller bearings, PLUS being SPLIT—right down to the shaft! For mounting, Cooper bearings are assembled around the shaft—not pushed or pressed on the shaft. They may be mounted where it is impractical or impossible to mount conventional solid race bearings.

The unique SPLIT feature saves "down time", money, and space. With Cooper bearings you get all the advantages of regular roller bearings with a Big PLUS!

Superb construction, high load-carrying capacity, and long life make Cooper Split Roller Bearings the first choice with designers and maintenance engineers.

Why not find out for yourself? Send for the latest catalogue and see what Cooper's big PLUS can do for you.

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PAGES 55-56 MISSING READER'S SERVICE CARD

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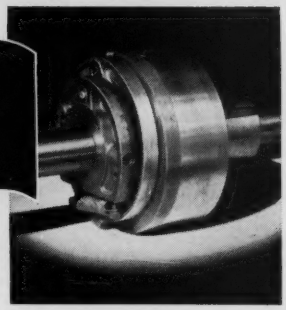
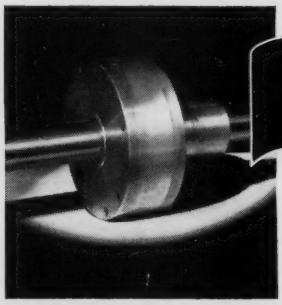
FOR POWER CONTROL DESIGNS

HILLIARD SINGLE REVOLUTION CLUTCH



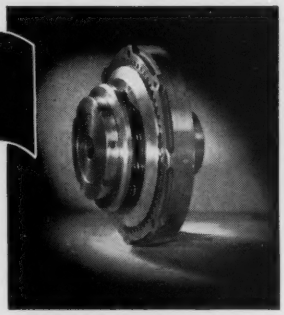
Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



HILLIARD OVER-RUNNING CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD SLIP CLUTCH



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

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C-5912

Circle number 119 on time saver card

New neoprene-jacketed coiled heater cord unharmed by 500,000 stretches

This new neoprene-jacketed heater cord was designed with a built-in coil action that eliminates tangling and tripping hazards between small kitchen appliances and connecting outlets. Concerned with the possible ill effects of continued flexing, the manufacturer subjected it to an acceptance test of 500,000 stretch-and-recovery cycles. Following the test, a careful inspection of the flexed sample revealed no damage to the heater cord — no sign of failure in its neoprene jacket.

Long-term flexibility, the subject of this test, is just one of the advantages offered by the neoprene jacket on this new coiled appliance cord. Neoprene also provides good resistance to the harmful effects of heat, food chemicals, cooking oils, greases, and other common household agents that quickly attack ordinary jacketing materials.

Neoprene synthetic rubber, made by Du Pont for 25 years, has become a preferred material in the design and manufacture of many parts used by the appliance industry. Compressible gaskets, oil-resistant seals, flexible boots, durable wire jacketing . . . all benefit from its unmatched combination of important properties. Learn more about neoprene and the Du Pont family of synthetic rubbers. Write to Du Pont of Canada Limited, Room 400, 85 Eglinton Ave. East, Toronto 12, Ontario.

Neoprene-jacketed coiled cord (type HPN) can be repeatedly stretched to its full length without affecting spring-back qualities or damaging the neoprene jacket.

DU PONT CANADA

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NEOPRENE
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VITON®
ADIPRENE®

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Cord can be used with all hand appliances, is self-storing, keeps work counter area neater and safer. Neoprene jacket resists food chemicals, oils, grease, and heat.

Circle number 139 on time saver card

HELP HIGHLY PAID LABOUR TO TURN OUT BETTER WORK IN LESS TIME.

Stelco Sems are pre-assembled Machine Screws and Lockwashers with inside or outside serrated edges. Their built-in locking devices reduce assembly operations and speed fastening jobs while providing improved holding power.

Sems are particularly effective where stress and vibration occur and often permit re-design because they can be used in cramped spaces and because with superior holding power fewer fasteners are required.

Where vibration is a factor in fastening — ask also for information on STELCO "Spin-lock" Screws.

Stelco will make a special Sem to fit your requirement if one of the many Standard types immediately available is not exactly what you need.

Contact any Stelco Sales Office.

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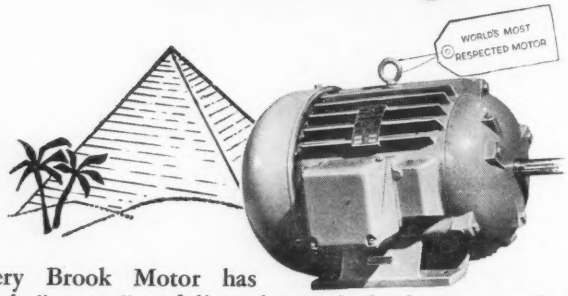

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OF CANADA LIMITED

250 University Avenue, Toronto, Ontario

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Briefs *(Cont. from page 52)*

is that they exist only where gases rise up through the earth from oil or natural gas deposits; germs live on these gases so where you find them you'll find oil or gas . . . **Brief Talepiece:** Even the hatpin is outdated. When a girl finds herself having to cope with any kind of assailant she reaches for her lipstick now. But instead of daubing her lips, she presses a button on the side of the case and Wolfie gets sprayed with a bright liquid which incapacitates him. Tiny paint bomb also emits high-pitched whistle when being used — and nearby men-in-blue stop writing parking tickets and rush to rescue, St. George-style. ★

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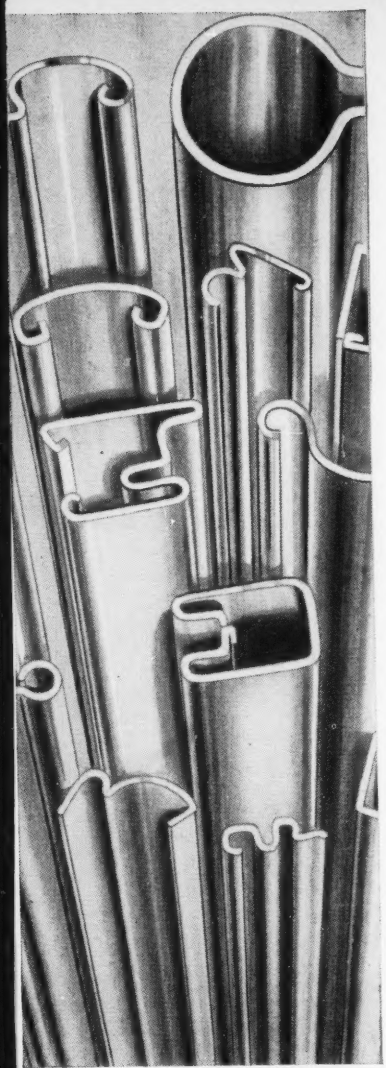

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Keeping informed

New booklets and technical data for you to read

Sprocket catalogue — this is a complete listing of stock sprockets and flexible couplings plus other engineering data. Published by Acme Chain Corp.

Industrial floors — a 24-page booklet discusses the merits of "iron-clad" concrete floors. Keyed MP-4d, it is offered by the Master Builders Company.

Power Saw — plenty of information about a new saw designed for heavy-duty cut-off work with 24-in. x 24-in. capacity. The DoAll Company.

Vibrator testers — vertical and horizontal mechanical equipment selectors are discussed in this folder. All American Tool and Mftrg.

Industrial pumps — a wealth of detail about Pioneer pumps which have a wide range of industrial use. The 72-page catalogue is put out by Detroit Harvester Company.

Miniature electrical connectors — exploded drawing, photos and line drawings illustrate this folder issued by The Deutsch Company.

Multi-purpose dumpers — how to handle bags, boxes, bulk, drums in a hurry concerns this leaflet. Essex Conveyers Ltd.

Air Conditioners — several forms of air-conditioning equipment for industry are illustrated in new booklets which supersede others printed for American Standard Products.

Hydraulic test cart — bulletin describes test carts for field use. Nankervis Co.

Packaged control systems — operation of push to start, through push to stop, are described in this booklet on automatic control. Clark Bros. Company.

Aluminum finishing — manual of chemical treatment methods for cleaning, etching, deoxidizing, descaling the stuff. The Frederick Gumm Chemical Company.

Recording — or as the booklet says, "new concepts in recording for military, industrial and scientific appliances." By Brush Instruments.

Compressors — of the horizontal, water-cooled, single-stage and heavy-duty kind. Eight page bulletin in two colors tells the story. Pennsylvania Pump & Compressor Co.

Polystyrenes — this 24-page booklet might bring you up to date on some members of the ever-expanding plastics family. The Koppers Company are publishers. ★

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Certainly, graders get their share of steering shocks and strains. And the engineers who design them expect it.

That's why grader builders so often furnish Blood Brothers Universal Steering Joints. From start to finish, they're soundly designed and ruggedly built to stand punishment.

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For general information, write for Bulletin 557.

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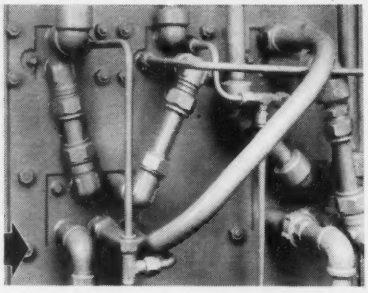
IMPERIAL *Engineering and Data Digest*

— ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS —



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IMPERIAL

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44 pages of important data with complete specifications, engineering drawings, installation details, numerous applications and instructions for ordering.

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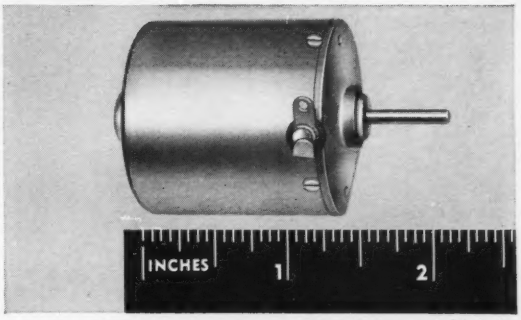
can you use this miniature d-c motor in your product?



inexpensive, yet high in quality, this compact governed d-c motor is available in speeds from 1500 to 5000 rpm. Designed to operate over a voltage range of about 4 to 30 volts d-c, it is ideally suited for many applications such as: drive mechanisms in photographic equipment . . . marine navigation equipment . . . portable dictating machines . . . signal-seeking radios . . . tape players . . . and many types of portable instruments. Is this the answer to *your* design problem, too?

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Editorial

What's in a name?

More specifically, what is meant by the term "design engineer?"

Since becoming editor of this publication, we have been attempting to establish a precise definition for this term. The more we delve into the subject, the more amazed we become. There would appear to be as many definitions, all of them based on certain justification, as there are experts to offer an opinion.

There are those who contend that the term "design engineer" is used too loosely in Canada. They would have it reserved only for those whose efforts are spent on designing what are known in the trade as end-products. These men are definitely designers; but to restrict the title to them would exclude all other design functions, like the tool engineer, process engineer, industrial designers and specification engineers.

On the other hand, we have been told that ". . . no matter what his job title or function, every engineer is called upon, some time or other, to pass judgment on an engineering design . . . even the presidents of our largest corporations are directly involved in design . . . every engineer is a designer."

Such is the divergence of opinion. And quite frankly, we seem to be as far as ever from a satisfactory answer.

Progress through education

We believe a milestone was reached when a group of Toronto businessmen sat down, at the invitation of this magazine, to discuss the future of the hydraulics and pneumatics industry in Canada.

As a result of the meeting there is good prospect of a Canadian Hydraulics and Pneumatics Association being formed this fall. As we go to press, a steering committee is lining up the details. Design Engineering feels privileged to have been asked to play a part in these preliminary considerations.

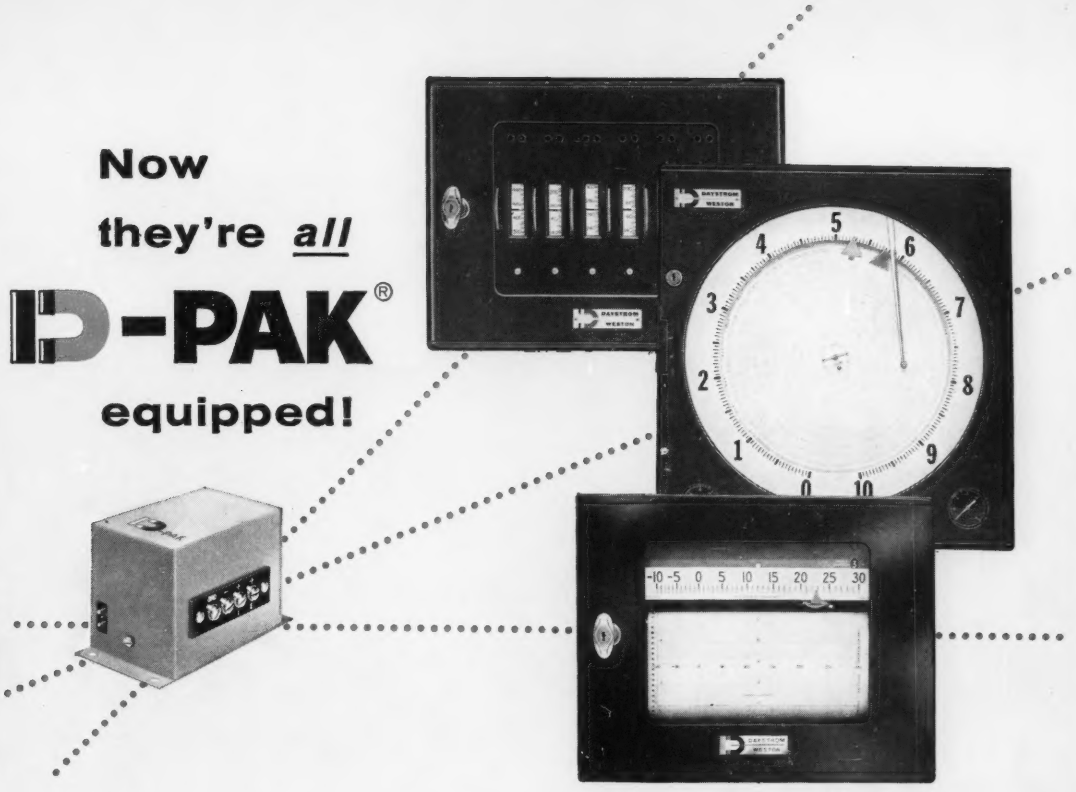
Indications are that the association will be open to everyone in Canada involved in hydraulics and pneumatics, including manufacturers, representatives and users. The chief interest of the group will be in educating the Canadian engineer in the design and application of fluid-power equipment.

The fluid power field has a great potential in Canada. It will be developed only through the education and co-operation of all; this encompasses both suppliers and users.

Until such time as the proposed association establishes a firm mailing address, DE will act as a clearing house for letters from all persons or companies interested in this venture.

Doug Kaill

Now they're *all* D-PAK® equipped!



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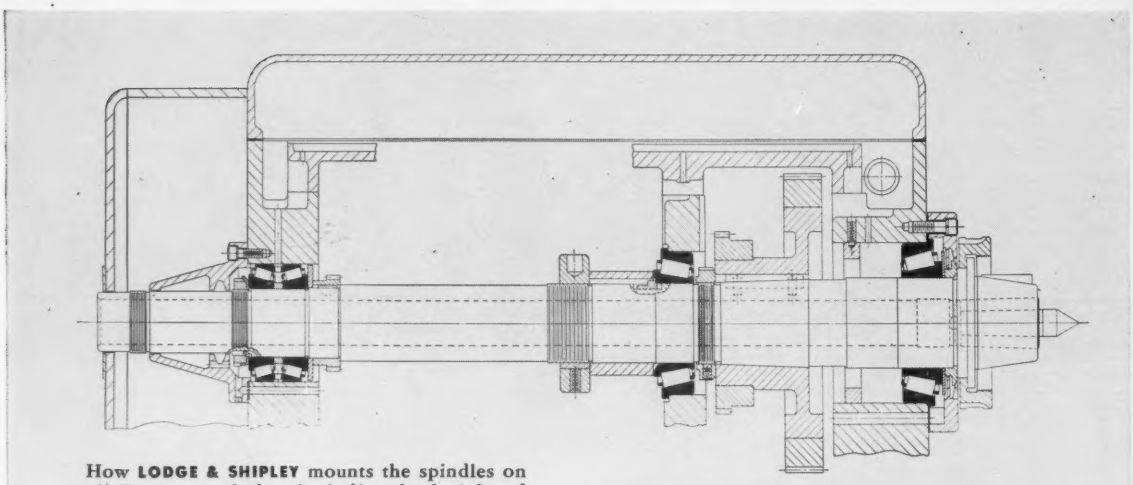
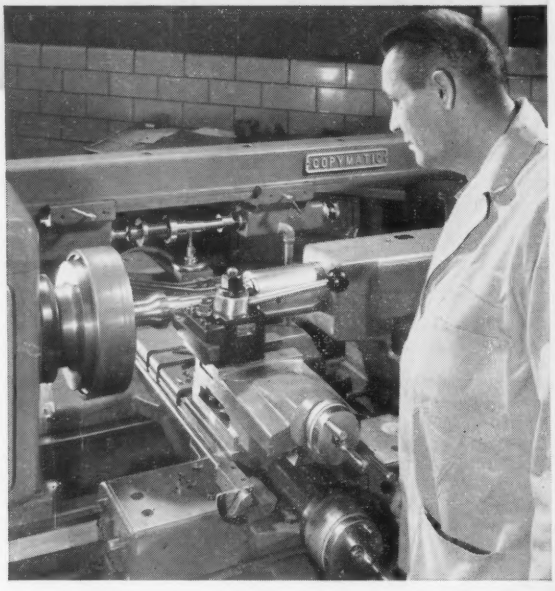


How **LODGE & SHIPLEY** mounts the spindles on all Powerturn lathes including both 45° and 90° Copymatics on Timken bearings to get extra rigidity, maintain accuracy, reduce maintenance.



New type lathe ups production 200%, saves users an estimated $8,000 a year

...one secret—TIMKEN bearings on the spindle

"Production increases as high as 200%"..."Overall savings estimated at $8,000 a year"—read user reports about the new Powerturn 90° Copymatic Lathe. One important reason for such exceptional results is that Lodge & Shipley mounts the spindle on Timken tapered roller bearings. Timken bearings give it the vital extra rigidity and hold runout to the minimum needed for tracer accuracy.

How spindle is held rigid. Timken bearings hold the spindle in positive alignment. They take *both* radial and thrust loads in any combination, because of their tapered design. And because of full-line contact between rollers and races, Timken bearings have extra load-carrying capacity.

Why heavy shocks are absorbed. Case-carburization of Timken bearings' rollers and races gives them hard, wear-resistant surfaces and tough, shock-resistant cores.

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